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THE INSTITUTION OF PRODUCTION ENGINEERS

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by E. C. Parkinson, M.I.P.E.

ELECTRIC FURNACE BRAZING
by George P. Tinker, M.Sc.

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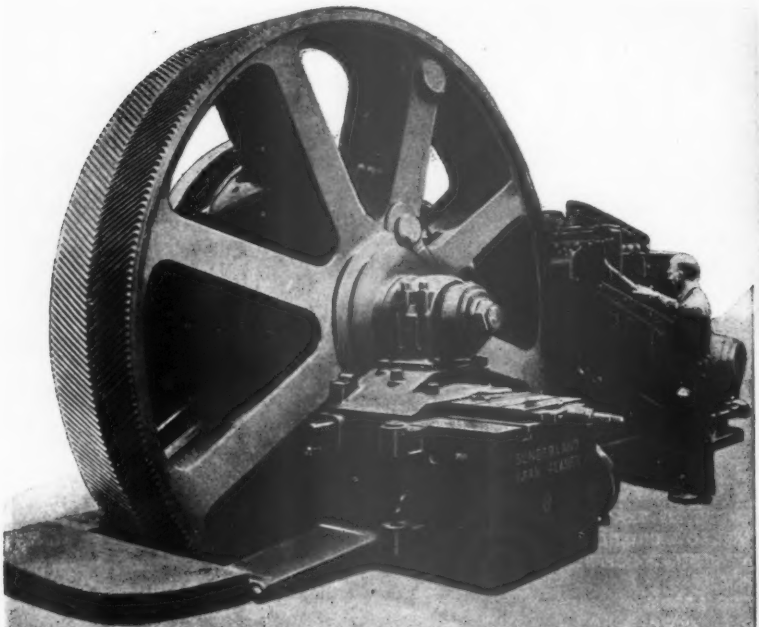

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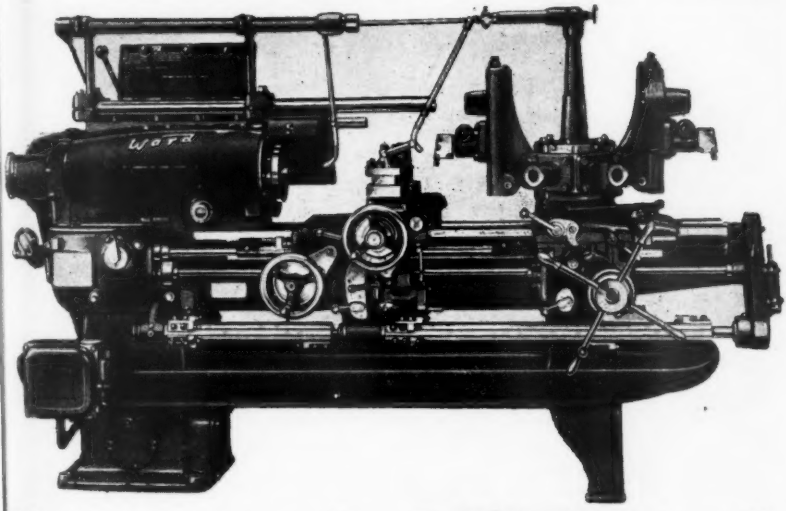

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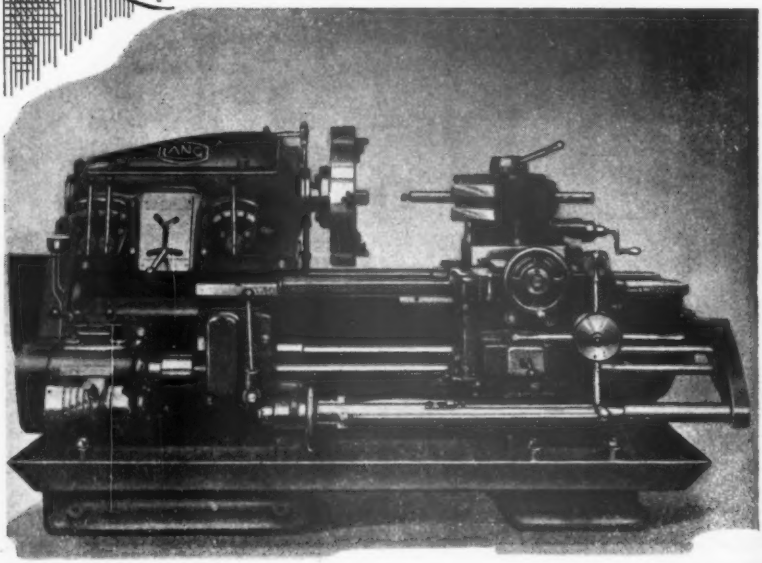

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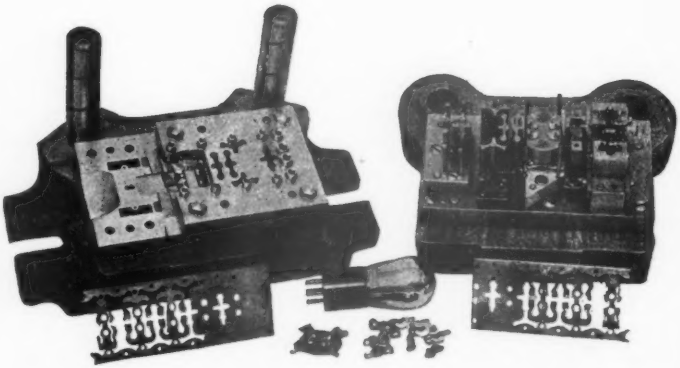

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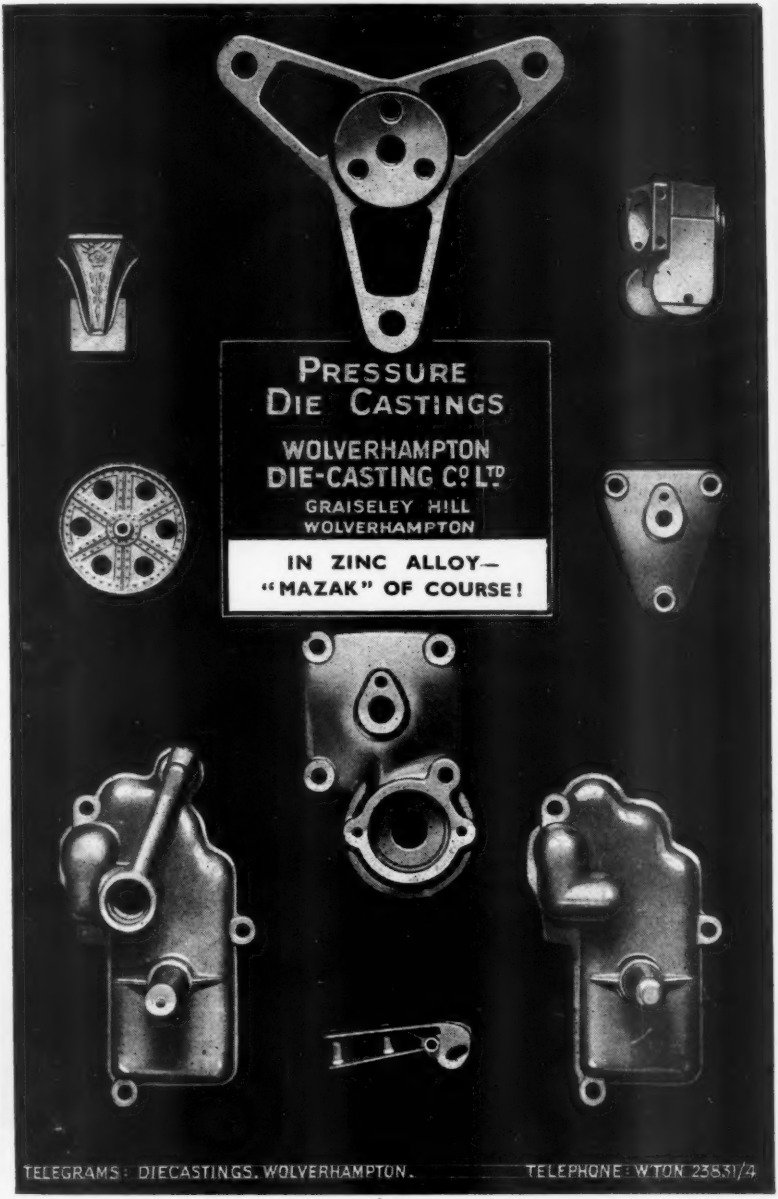
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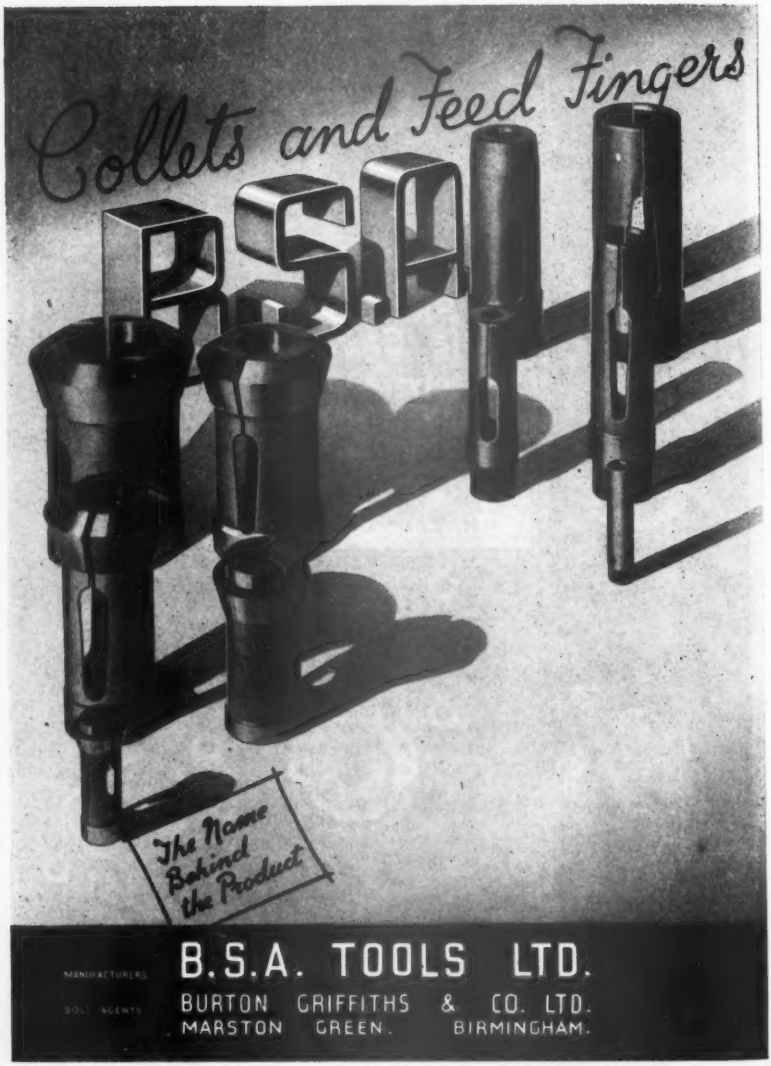
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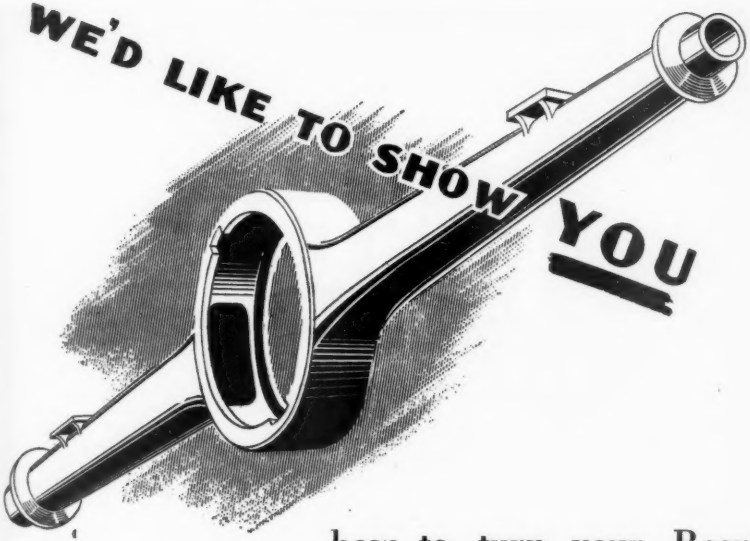

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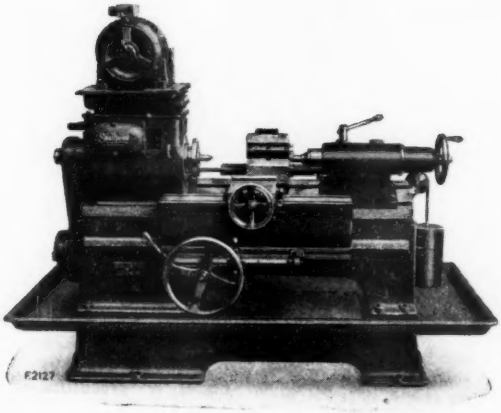

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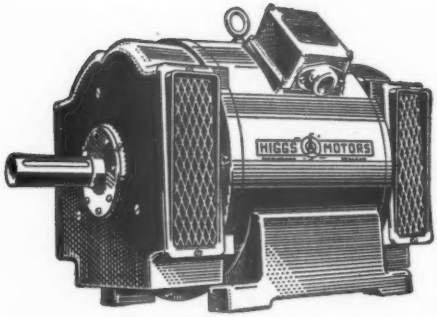

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THE EDUCATION AND TRAINING OF PRODUCTION ENGINEERS (IN AUSTRALIA)

By E. C. PARKINSON, M.I.P.E.

"As an indication of the active forward look of our Australian Members, we would refer to our Common Ordinary Certificate and in this connection would state that our Education Committee are deliberating on this matter with the idea that the principles of production should be included in this Common Certificate."

To approach this problem it is essential that we are clear in our minds of two things at least—what is a Production Engineer and what do we consider to be the essential qualities of a Production Engineer.

A Production Engineer.

The British Central Register defines a Production Engineer as "... a staff engineer who normally holds in any engineering works a position of authority involving responsibility for executive management or control (above the rank of foreman) of any technical function pertaining to production".

I should like to go further than this and define a Production Engineer as a trained engineer capable of setting in motion, guiding and controlling the many forces required in an engineering works, to make :—

(*a*) what is required,

(*b*) when it is required,

(*c*) at a profit, at a price the client will pay.

This sounds simple, but let us look at it a bit closer. Frequently this has to be done with the minimum amount of expenditure on machine tools, jigs, fixtures, etc., so that he must be able to make the fullest use of what he has available and with the labour force available at the time, whether skilled or unskilled.

To do this he must have personality, strength of purpose, untiring enthusiasm and energy ; definite sales ability, tact and ability to work with all types ; sufficient "elasticity" to take many knock-backs, ability to carry out a critical analysis of any problem arising out of his work and over all this, ability to put over his progressive ideas to what is often not a very progressive management or board of directors.

It is quite obvious then that the requirements are very exacting.

Fortunately, men are in industry to-day who fit the above pattern and they made possible the manufacture of all types of equipment in pre-war days. When war began the full burden of production fell on them. It must be agreed that they have done a magnificent job.

We have had no established courses of training in Production Engineering which have been in operation long enough for us, in this country particularly, to see any results. It appears somewhat strange, looking back, to think that we have had for many years excellent technical college and university courses to train mechanicals, electricals, chemicals, civils, and so on ; all these engineers creating, or tending to create, goods which have to be produced in engineering workshops. Many large firms have for years operated excellent engineer training schemes, but a study of quite a number reveals the fact that they have concentrated practically wholly on the training of engineers for design, research, sales and technical representatives at home and abroad, and so on, with the result that "production" had to look after itself and shall we say "just grow up".

It is stranger still when one analyses the products manufactured by these firms and finds that they are goods of a highly competitive nature—not only a number of firms manufacturing similar goods, but other countries also in the field.

One can only feel then that in the "growing up" process our production engineers have in the main followed a course of training which has produced some very outstanding men.

I cannot deal with this paper from the point of view of the educationist, I am an engineer and my approach to this problem will necessarily follow the lines of my approach to any engineering problem.

We have then an established product—a production engineer, much the same as we might have a good engineering product. Well, how was it made and what makes it good ? As is usual in any good engineering product, an analysis reveals good fundamentals, in-built quality, good appearance and finish. Think of any men you know as engineers to whom you would give the title of production engineers and what do you find—good fundamental knowledge, in-built, or cultivated qualities, good appearance and "finish". I find it hard to think of any man to whom I would give the title of production engineer not possessing these qualities.

Does this give us some idea of our requirements ? I think it does and on it I base the following parts of this paper.

The requirements are then :—

(*a*) Good fundamental knowledge.
(*b*) "In-built" qualities.
(*c*) Good appearance.
(*d*) Good "finish".

Having cleared our minds on what a production engineer is and the requirements of a successful production engineer, we can now approach the problem of education and training.

Selection.

However, before proceeding, let us first deal with selections. Our engineering training teaches us that one of the pre-requisites of a good product is good material. Let us then start with good material, otherwise we shall never turn out the finished product no matter how much education or training we put into the job.

The embryo production engineer must be in good health, have good appearance, be a good mixer and must show signs generally of the "in-built" qualities we require. The Lone Wolf type is no good to us at all. We must have men capable of working with a team and not as individuals. Consequently, the later we can leave this selection or the older the prospective production engineer is, the better chance of correct selection, but against this we must get them young, as we have so much to teach.

A great deal has been written about the selection of employees for specific jobs and in many companies a very extensive selection procedure has been developed. This has developed out of a recognition of the impossibility of determining by mere casual observation which applicant is the most desirable, although it cannot be denied that such judgments have formed the most important basis for selection in the past.

The selection of materials receive a great deal of thought from all of us, let us then be careful and use all available tools in the selection of trainee production engineers.

In one of the recognised standard publications on personnel management—"Personnel Management and Industrial Relations," by Dale Yoder, 1942—I recently read something like this :—

> "Vocational guidance is a function of personnel administration that many personnel managers would like to avoid, but it appears as an almost inevitable accompaniment of selection and placement. The fact is that vocational guidance is an inescapable feature of selection."

There must be a very well considered approach to this matter of selection and the days of father and mother wanting their son to be an engineer and knowing someone in an engineering works, as an act of friendship have the lad given a position, must go. The son must want to be an engineer and by recognised tests show that he is good material to try out.

What then is the standard of education required and at what age do we start to train ?

General Education.

It is interesting to see what others think of the educational standard required for engineers :—

(*a*) In our Journal Vol. XXII, No. 3, March, 1943, we have a paper presented to the Institution, Yorkshire Section, by J. D. Scaife, M.I.Mech.E., M.I.P.E., from which the following quotation is taken :—

> " From my own experience I would say without hesitation that a 16 years old grammar schoolboy of average mental capacity who receives a well-balanced shop training under good supervision will be more advanced at 19 years of age than the ordinary elementary schoolboy at 21 years of age and the superiority becomes more marked with further experience. . . . Shop training for a craftsman from 16-21 years of age is probably quite satisfactory for the average youth, but I am strongly of the opinion that it is two years too long for technological students who are destined for the higher executive posts in engineering.
>
> " These, I believe, will be selected in some manner satisfactory to industrial and educational authority and will proceed to some State-controlled educational establishment of the public school type for two years' vocational training by specialists in an atmosphere which preserves many of the best characteristics of the present day public schools. The latter, we presume, will be non-existent for lack of financial support.
>
> " The Public School of the New Order (and which, I may say, is not so visionary as some of you may imagine) will have for its objective :—
>
> (i) To develop powers of leadership, sportsmanship, and self-reliance in an atmosphere free from the softer influence of home life and fond parents.
>
> (ii) General education to the university entrance stage and technical education to the ordinary National Certificate examination.
>
> (iii) Approach to practical technology and elementary machining operations in suitably-equipped workshops.
>
> (iv) Physical culture appropriate to the individual in the widest sense.
>
> " At 18 years of age the budding production engineer will then commence a three years' apprenticeship course, which will include a general training in machining operations, machine erecting and equipment design.
>
> " The Higher National Certificate course, taken at an

evening technical college between 18 and 21 years of age, will complete a further stage in the training of a production engineer.

"For those who select (or who are selected for) a purely works executive career, further training should continue in planning, equipment design, time study, etc., as circumstances will allow in the particular organisation concerned, after which a minor and progressive post should be sought for the sake of experience."

(*b*) The Commonwealth of Australia, Ministry of Munitions, recently invited applications . . . from persons between the ages of 18 years and 23 years, desirous of appointment as Cadet Engineers for training as production engineers of the department.

Appointees will be allotted to a factory of the department and may be called upon to serve in any State of the Commonwealth. The term of cadetship is for five years, during which the department will pay university fees for appointee to complete the degree course in engineering at an approved university.

Qualifications required :—

(i) Matriculation plus science or engineering diploma; or

(ii) Completed first year Engineering Degree Course, Australian University.

(*c*) The Broken Hill Proprietary Company, Limited, who for many years have operated an Engineer Training Scheme, require applicants eligible for appointment as :—

(i) Technical Cadets, to be graduates of a recognised university or School of Mines or hold a diploma from a recognised technical college in metallurgy or some engineering science.

(ii) Technical Trainees, to have gained the Leaving Certificate or equivalent.

(*d*) Some of the larger British firms require a sound general education such as is provided by a public school, or a secondary school up to a School Certificate (or, preferably, Higher School Certificate) standard. B.T.H. then recommend 12 months in a large up-to-date engineering works, followed by a university or full technical college course in engineering, of not less than three years' duration and preferably leading to an Honours Degree.

Metropolitan-Vickers Electrical Co., Ltd., in their booklet "Education for Industry", make similar recommendations.

(*e*) The General Electric Company of America has a Factory Training Course—for a limited number of engineering graduates who are interested in work of an executive nature in the manufacturing organisation.

This all indicates the necessity for a good general education and I submit that a pass in our Leaving Certificate in subjects required for Entrance to the University or Technical College Diploma Courses, must be a pre-requisite to selection and that more consideration should be given to engineering graduates for training as production engineers.

In the case of the Leaving Certificate lads, the average age will be about 17 years of age, graduates about 21 years of age.

Technical Education.

It is likely that most appointments will come from lads of Leaving Certificate standard who will have to receive their technical training by attendance at recognised technical colleges in the evenings or part day and part evening or perhaps later in some form of "sandwich" course, to a Diploma Course standard.

To complete a Diploma Course as an evening student whilst actively employed in a factory during the day is a feat of endurance few can perform. Reports from Great Britain indicate an excessive falling off of students between the first year of the ordinary and the final year of the Higher National Certificate courses.

It is interesting to see what is happening in our Sydney Technical College. A recent report gives the following :—

WASTAGE OF 1937 AND 1938 ENTRANTS TO DIPLOMA COURSES.

Course.	No. entering course.	No. attending in 1941 (or completed Mech. Eng. Diploma).	No. up to Schedule in 1941.
1937 *Entrants*			
Electrical ...	48	13 (27%)	8 (17%)
Mechanical ...	44	25 (57%)	14 (37%)
1938 *Entrants*			
Chemistry ...	48	18 (37½%)	12 (25%)
Electrical ...	61	36 (59%)	23 (39%)
Mechanical ...	77	30 (39%)	21 (27½%)

It is very interesting again to refer to Mr. Scaife in the Journal previously quoted, in which he says :—

> "In the matter of technical education of production engineers and managers, the older generation has had to shift for itself. Employers were generally not sufficiently interested to grant special facilities and day classes for apprentices were unknown.
>
> "A comprehensive study of the ordinary mechanical engineering subjects meant the burning of much midnight oil

and drawing on the physical and mental resources of the student.

"Strange to say there were many who survived the strenuous ordeal and lived to tell the tale to their less fortunate and enduring fellows, but there were many who fell by the wayside on account of sheer physical exhaustion.

"This method, being dependent on endurance and willpower under adverse conditions, was obviously bad."

In the vote of thanks to Mr. Scaife, proposed by Mr. Sykes, M.I.P.E., the following was stated :—

"To take the entire course in the evening school is too much to expect and I believe any of us who have gone through that experience will be sufficiently generous not to wish young production engineers to have to go through it. It is not good physically or mentally and it drains the energy of a young man to such an extent that it takes a long time to recover."

We here to-night realise, I am sure, that a production engineer has to be tough, but is it necessary to put all our budding trainees through such a course when we know so few can possibly stay the distance ? The need for production engineers in this country is surely far greater than can be satisfied by such means.

The technical training of production engineers in England, thanks to the strenuous efforts of our Institution, has been put on a very sound basis. There we have what is known as :—

(i) The ordinary National Certificate Course in Production Engineering.

(ii) The Higher National Certificate in Production Engineering.

(iii) The Post Higher National Certificate Stage.

The ordinary National Certificate Course provides the preparatory work for the Higher and in Appendix 2 of "Higher National Certificate Course in Production Engineering," Board of Education, 1941, is set out the minimum that should be covered prior to entering the Higher National Certificate Course.

The Board of Education's notes for the guidance of Colleges and Schools on the arrangement of courses for Higher National Certificates in Production Engineering states in Sections (7) and (8) :—

"(7) The courses must include those subjects which are fundamental to Production Engineers of all types, and the following are regarded as essential and appropriate:—

(*a*) The workshop processing and fabrication of the materials used in engineering construction, including a study of machine tools. The relative costs of alternative materials, processes and methods of fabrication.

(*b*) The physical properties of materials used in engineering. (A study of these will involve some metallurgy and heat treatment.)

(*c*) The science of fine measurement as the basis of interchangeability and of production.

(*d*) The principles of construction of gauges, jigs, and fixtures.

(*e*) Those parts of the subjects Theory of Machines and Strength of Materials which have a direct bearing on workshop operations and motion study.

"(8) The mathematics essential for the treatment of the foregoing subjects should be embodied in the course."

In Section (5) it states :—

"(5) Subjects such as the Administrative and Managerial Group which clearly require experience and a more mature mind for their comprehension should be deferred to a post Higher National Certificate stage."

The Board of Education's Notes referred to were published in full in the Journal, December 1941, and the suggested Syllabus for the Post Higher National Certificate, in the Journal, July, 1942.

Time will not permit going through these in detail, but to those of you who are interested in the problem of education and training of production engineers, I would suggest that you read the Journals mentioned to get a full appreciation of what has been done by members of our Institution in England and also to realise fully the amount of ground to be covered.

In Australia we have no courses of instruction approaching those of Great Britain.

Members of the Sydney Section have worked very hard for some three or four years to have a full Diploma Course in Production Engineering established at the Sydney Technical College, but have been unable to do so mainly because the munitions programme has been so intense that men who would be suitable as lecturers in such a course have not been available to the technical college. All that we have been able to do, and which we consider to be a big step forward, is to have established a two-year Post Diploma Course in Production Engineering. It started early this year, after a considerable amount of work by a number of members, assisted by Mr. J. Tainsh and later by Mr. Bruce Brown of the Sydney Technical College. Details of the course were made available to all members and forty students enrolled. Many more than this were anxious to take the course, but again because of the difficulty in obtaining lecturers, the number had to be restricted to forty. Mr. J. E. Strick, a member of the Institution, was appointed as Co-ordinator of the

Course and has done a really fine job. To him our thanks are due, also to members and others who so willingly came to our assistance as specialist lecturers. No doubt additional lecturers will be required next year when it is hoped a further forty students will commence studies and second year lectures will have to be given, but we feel confident that we shall be able to provide them when the time comes.

Most things start from small beginnings—here in 1944 we have forty students, as far as I know, in the whole of Australia receiving specialised instruction in production engineering subjects. Certainly most of these have already completed a Diploma Course, in either electrical or mechanical engineering, and for many years our Technical College has in these and other Diploma Courses provided instruction of a very high order. Many men have availed themselves of this instruction and have received their production training in the engineering workshops of New South Wales and other States. Similar courses have been available in the larger Technical Colleges of this and other States. However, it is the considered opinion of the Education Committee of this Section, that the Technical Education of Production Engineers will not be on a satisfactory basis until a full diploma course, plus a post diploma course, in production engineering is established in the major technical colleges, not only in New South Wales, but in other States too.

I consider that the Diploma Course in Production Engineering should be a five-year course, the first three years being identical with the first three years of the established mechanical and electrical engineering courses, the following two years to be devoted to instruction in production engineering subjects on the lines indicated for the Higher National Certificate and to be followed by a Post Diploma Course of one or two years dealing with the administrative and managerial subjects.

There can then be no real difficulties about the first three years to provide the basic fundamentals, and the Industrial Management Courses are now well established in Sydney and other technical colleges and will, with very little modification, take care of the Post Diploma Course. All that is now required is to fill the gap of the two years instruction in production engineering subjects.

We feel that the technical college authorities in this State now realise fully the need for this gap to be filled as quickly as possible and the Sydney Section of the Institution intend to keep this matter before them regularly until such time as the full course is well established.

The instruction now being given in the Post Diploma Course is of a very high order, as in practically every case lectures are being given by members of wide experience who can be considered specialists in the subjects they are handling, but these men are all holding down very responsible positions in industry and are carrying a very heavy

load. We cannot consider the present arrangement as one which can continue for long and we must ask the technical college authorities to deal with it.

When the course outlined is established industry must decide whether or not it considers the technical education of production engineers a matter of sufficient importance to grant special facilities for training. Such an intensive study is required—extending as outlined over some seven years, that I personally think trainees should be given at least eight hours per week daylight training in the first five years, the balance being covered by evening studies. There will be some loss in production in this period, but it will be amply repaid in later years.

We are concerned with the training of professional engineers, but I feel that I would like to stress the necessity of keeping an eye on the trade apprentices for those who can be picked out and put in the professional group for further training.

The university training of production engineers is another matter about which much can be said, but I do not propose to say more about it than to call to your attention a very excellent paper presented to the North Eastern and Yorkshire Sections of our Institution, by Dr. Geo. Schlesinger, published in the Journal in June, 1942.

Dr. Schlesinger was for thirty years professor of production engineering at a leading technical Continental university and I certainly recommend the study of this paper to those interested in graduates as production engineers.

Technical education of production engineers is receiving a considerable amount of attention overseas and one can quote a number of organisations already dealing with this problem or planning to deal with it. I will quote two cases :—

The first, reported in *The Times*, 6th November, 1943, in which we read the following :—

> " Developments of a far reaching character are envisaged in a scheme inaugurated by the Nuffield Organisation.
>
> " Free technical education, scholarships to the university, and special dietetic supervision are included in the responsibilities undertaken in this long-term plan for the encouragement of youth and the production of persons trained specially to play a leading part in home industry and in the development of Britain's world markets.
>
> " The educational policy is based on a regular intake into each factory of the organisation of a number of approved apprentices, who will be graded on performance and progress, scholarships to the university being paid for by the organisation for those apprentices who show the most promise."

The second is taken from " *Fortune*," December, 1943. The

article is headed " Executives Made to Order " and in it this passage is read :—

> " Only one civilian activity, the war-production training course, has survived the conversion of Harvard's Graduate School of Business Administration to teaching army, navy and air force officers. Yet in its implications for the re-education of U.S. management, this course may prove more important, in the long view, than any military curriculum."

Training.

I should like to preface my remarks on this by an extract from a lecture on " The Importance of Management Training for Engineering Students," delivered by Lyndall Urwick, at the University of Cambridge, in January, 1942, in which he states :—

> " In my own experience it is still rare to find high administrators, whether in the public service or in private employment, who escape the ordinary human dislike of contemplating a world relieved of their unique contribution. The subject of training those who are to succeed them is neither popular nor one that they are inclined to face realistically. The elective bodies common in central and local democratic government are apt to take even shorter views."

Production engineers generally realise the absolute necessity of having a definite plan to work to in all things. Design is planned, materials are planned, tooling is planned, production is planned and many other things, but how often is the training of engineers or apprentices planned ? In some works not at all, in others some attempt is made, but it is not followed through, and in a few, very few, it is done well. It is strange that one of the most important parts of our work is done so badly. Is it that we fit the higher administrators mentioned above ?

You may ask is all this worth while and what is the use of going to all this trouble to train a production engineer when as soon as he is trained he will be tempted away by one of our competitors ? It can be said that by the much approved process of competition, to educate and train an engineer is often in reality a slow way of sacking him.

You have heard this sort of thing very often, so have I. Well what are we going to do about it—all decide that there is no sense in training engineers for someone else and so do nothing about it or are we all going to tackle it as it should be done and make a job of ' If we all tackle it properly it will not be long before we have a group of engineers we can feel proud of—men who will play very important parts in the development of industry in this country. I make the assumption that we agree to train production engineers

and continue this paper. In doing it then let us use tools with which we are familiar—planning and progressing. Let us plan our method of training and by progress reports see how it is working out. The plan will depend very largely on the organisation the young engineer enters—some will have better facilities than others for training, but a plan can be made in any organisation and should be made before the engineer starts work.

This is what Mr. Scaife said in his paper :—

> "If a firm is in need of a certain number of production engineers, it will obviously obtain the best results in the shortest time and at the least expense by careful planning of each stage of the practical training. This planning should take into account both the theoretical training and the past experience of the individual. The length of his stay in each department and the work he is given to do should be determined by the plan and not by the requirements of works production. Similar planning should also be applied to his later staff training and, again, the requirements of a department should not determine his stay in that department."

Continuing this theme, a firm needs production engineers for the production of products it manufactures and its plan will be to give the young engineer the best possible training it can in all phases of production required to produce its products. The basic requirements are :—

(*a*) A thorough workshop training in as many departments as possible so that he becomes familiar with all machine and other processes carried out by the firm.

(*b*) A fair training in toolmaking.

(*c*) Some experience in tool designing.

(*d*) Some experience in the design of the products manufactured.

(*e*) A short period of training in the firm's methods of dealing with planning, rate-fixing, progressing, payment, stores methods, overhead expense and cost accounting, industrial management, welfare, etc.

In the case of the young engineer commencing at the age of 17 years, I suggest the above basic training should be somewhat along these lines :—

(*a*) 18 months' general workshop training.

(*b*) 9 months' toolroom training.

(*c*) 9 months' tool design training.

(*d*) 12 months' product design training.

(*e*) 6 months' general training as outlined in (*e*) above.

(*f*) 6 months as assistant to a senior foreman or a superintendent on production.

This completes five years of training and at the end of this period the young engineer should be given a position of responsibility on the production side to round off his previous training and advanced to further responsibilities as he progresses and opportunities arise.

The ground to be covered is so great that training must surely commence the first day the lad enters the firm's premises. We are gradually getting out of the stage where our young engineers had to start doing the odd jobs about the shop, sweeping the floor, boiling the billies, or filling in time in the store.

In large organisations an engineer can be set aside to devote the whole of his time to the supervision of training of young engineers, but in smaller ones this is not possible, but it should be one senior man's responsibility to check their progress both by personal contact and by progress reports.

To ensure proper training in both large and small firms the supervisory staff and tradesmen must be brought in to the plan as there is so very much they can contribute. It must be made very clear to every supervisor that when a lad is sent to his section for training he must be trained and not just used on the odd jobs in the section. If there is any reluctance on the part of supervisors to training lads, and even with their full co-operation, it is a sound idea to set out the minimum a lad must be taught whilst in any section—a copy of this being given to both the supervisor and the young engineer.

Progress reports should be made out in a standard form by all supervisors covering the period served by the trainee in their sections or departments. A standard form of reporting has many advantages, it saves time for the supervisory staff, is simple to fill in, forms an excellent basis for any proficiency award scheme which may be introduced and keeps the matter of training in the foreman's mind. In addition to the reports from the Supervisory staff the young engineers themselves should furnish a report covering one and a half to two sheets of foolscap, telling what they did, what they saw, and what they thought, in every section in which they work. Where they are in one section for periods exceeding three months they should furnish a report every three months. Every report furnished should be read by a Senior Officer, acknowledged and commented on, guidance being given where necessary. The reports are an excellent means of checking the trainee's progress and developing his powers of observation and expression, as well as providing excellent training in report writing. They serve many other purposes too and I am sure any firm will find these reports of great value.

The trainee's progress in his technical studies should be checked either from the reports furnished by the technical college or where these are not forthcoming by contacting the college authorities and asking for progress reports. When the reports are good a congratulatory note to the lad means a lot. Where they are poor an

effort should be made to find out why and any possible assistance and guidance to improvement should be given. Where a number of trainees are employed, annual awards for meritorious work could well be used.

To round off the training, visits to other organisations should be arranged whenever possible and after each visit a written report called for—if these visits are only made possible for the lads who have played to the rules of the firm they are employed by, it has quite a good effect on any who may not be making fullest use of training facilities provided. More consideration should be given to visits to other firms than is given at present.

The training of the graduate entering a works at the age of about 21 years, will differ considerably from that of the trainee commencing his training at 17 years of age. We assume that he has had some workshop experience, either in the university or during his long vacations and consequently his workshop time can be shortened.

Dr. Schlesinger, in the paper previously referred to, said he was convinced that the education of the successful production engineer must be based on :—

(*a*) A thorough knowledge of design and its preliminary calculations in mechanical engineering.

(*b*) A practical training in a well-managed workshop equipped with modern machines and tools, divided into :—

(i) A thorough course of general workshop practice of one or two years (foundry, pattern shop, fitting and erecting, and all important mechanical departments of a well-equipped machine shop).

(ii) A short course of works administration of about three months, comprising the study and application of economic methods of production planning, rate-fixing, routing, payment, stores, overheads, cost accounting.

The graduate will have a good knowledge of design problems and mathematics. It will be, no doubt, necessary for him to add to his design knowledge by spending some time, say six months, on design problems of the works he enters, after he has done a workshop training period of eighteen months. His next training period being a short course of works administration of approximately three months and to round off his training a further period of three months as assistant to a senior foreman or superintendent on production. Then, as with the five-year trainee, he should be given a position of responsibility in production.

At the end of this training both groups are ready for, and capable of, taking responsibility. They will thrive on it. Their training is not yet completed by any means. A scheme such as outlined above will bear good fruit which can only be ripened by good experience

gained in positions of responsibility. Let us not say he is too young for the job, but rather that young as he may be we will give him the job. He will do it and make no more, perhaps less, mistakes than we have.

Conclusion.

This concludes my paper. We have selected and trained a production engineer. We have provided for good fundamentals; by selection and subsequent training we have done as much as we can regarding "in-built" quality and appearance to produce a product of good "finish." Let us hope we have trained a man, for it is said that to become a manager you must first become a man; and to become an educated man there must be some content of humanism in your mental make-up.

A report of 1936 contains a passage which, I think, we could well bring before our young production engineers. It is this:—

> "The engineer of tomorrow will not rise to leadership by abandoning his distinctive role or by permitting it to become ill defined. He will do so by remaining essentially an engineer, by becoming a more competent engineer, by extending the reach of engineering methods and ideals to larger realms of life and withal, by making himself a team-mate eagerly desired by other types of men."

DISCUSSION.

MR. MCPHEE: When I was honoured by being requested to comment on Mr. Parkinson's paper, I hoped the job would be easy in that I expected to find more points with which I disagreed. Actually I found very few and was especially pleased at the emphasis placed on what might be called the personality and character factors required in good production engineers.

My comment therefore will be mainly an emphasis and enlargement on what I consider some of the more important matters touched on.

(1) On the question of definition of a production engineer. Discussion will continue I believe for some years yet. The term is comparatively new and is not yet generally understood in the community. It is important that it should be defined and generally accepted. I agree that the term should only be used for an engineer able to initiate, guide and control the many forces entering into production. He should have some knowledge and, if possible, practical experience of such things as rate-fixing, production control, jig design and control of labour and some experience of machine operation, but if a specialist in any one of these, without much understanding of the others, he is not a production engineer, but rather a rate-fixer or draftsman or tool designer, or foreman, or any one of a number of other classifications.

(2) On the question of qualities required of a production engineer, Mr. Parkinson quoted from Mr. Scaif's paper of March, 1943. In this paper Mr. Scaif suggested a division of production engineers into production engineers and production administrators. For both he advocates a better preliminary education than we have hitherto considered necessary. I am strongly of the opinion that he is right.

For production engineers proper, apart from the necessary specialised technical subjects, he suggests at least leaving certificate to be followed up later by such subjects as industrial history and sociology. I would add such subjects as economics and industrial psychology. For production administrators, he believes that university graduate standard of general education is called for and that the following four characteristics are more important than technical achievements and ability :—

(1) Administrative ability.

(2) Strength and integrity of character.

(3) Sound judgment.

(4) Imagination.

Mr. Parkinson has wisely added to these energy, enthusiasm and the all-important ability to take knock-backs and try again.

(3) The question of selection was mentioned. Granted that the use of psychological tests may not be 100 per cent. effective, it has been quite definitely proved that combined with the older methods of interview and references, they are much more effective than the older methods alone. It may not be generally known that the techniques of vocational psychological testing are improving very rapidly during this war period and these improved techniques should be widely used by industry after the war, when people trained in their use should be available.

(4) Mr. Parkinson drew attention to the "wastage" at the Technical College of apprentices doing the evening course. The percentage of students "falling by the wayside" will almost certainly reduce with the partial day-time training just commencing. I believe too that there is room for much closer co-operation between Technical College and the factory where the boys are being trained.

As one of the older generation who survived full-time day work and years of three to four nights of evening classes, I agree that this is too great a strain on the strength of the average boy.

(5) With regard to the present production engineering course, we may expect this to change with a clearer definition of requirements, greater experience with subjects and times allotted to these, and the results in the way of trained students. Constructive criticism and suggestions made by students and interested employers will undoubtedly be of value to the Technical College or to the Education

Committee of this Institution in investigation of changes desirable.

I believe that we are all agreed that the course should develop into a five-year diploma course with the first three years common to "Mechanical Engineering." On this basis a student need not decide until the third year whether to proceed with the mechanical diploma or the production engineering. The final two years should also be available as a post-diploma course for electrical or mechanical diplomas, and as a two-year certificate course for university graduates in engineering or for older men in industry, perhaps without diploma or degree, but with educational background and experience and present responsibilities which justify inclusion.

(6) In connection with the "training" of the student in the workshop where there is no special apprenticeship school and it is probably only the few large factories which will run these, it is necessary for someone detached from immediate production, *e.g.*, a welfare officer or planning supervisor, to schedule the work of each apprentice and to ensure that the programme is adhered to. A Ghant chart is useful in this regard, in all but the smallest factories where the apprentices will be under the direct control of the manager.

There is a temptation for a foreman of a particular specialised section to hold on to an apprentice when he finds him useful.

I have no doubt too that more visits between factories would be of value in training.

I suggest also that the question of temporarily exchanging apprentices between factories might be explored. This should not prove too difficult between non-competitive factories especially. I am speaking, of course, of peace-time when we may hope that manpower difficulties will not prove a barrier.

(7) Here in Australia in the past, for various good causes, the university graduate has given preference to design jobs and has only entered the factory on the production side in very small numbers. A change is required to make it possible and attractive for more university trained men to enter the factory.

(8) Mr. Chairman, I would be pleased if Mr. Parkinson would further comment on some of the matters touched on.

MR. PARKINSON: I agree with Mr. McPhee that a more satisfactory definition for a production engineer is required.

In the paper no attempt was made to deal with what Mr. Scaife referred to as production administrators. I feel that administrative positions can be filled very satisfactorily from engineers trained as outlined in this paper.

I was very interested to hear Mr. McPhee's comments regarding the use of vocational guidance tests as part of the selection procedure.

Regarding the training of engineers in the workshop, I do not feel that it is necessary to have any special apprenticeship school, but it

is essential that some responsible officer, preferably an engineer, be set aside to consider in detail the schedule of training and to assist and guide the young engineers. When the schedule is laid down a considerable amount of policing will be necessary to ensure that the young engineers are being trained and not being used solely to meet the requirements of production in the particular section of the factory in which they are employed.

Visits between factories can be very helpful. Unfortunately, today there are too few factories who will permit visits of this kind.

The matter of the employment of university graduates in production engineering is one that is likely to be taken care of only when industry makes known its requirements on a forward planned basis, to the university authorities. It is probably safe to say that few graduates have any idea of the possibilities of a career in production engineering.

MR. STRICK: The education and training of engineers and in particular production engineers, is a matter which should be of vital concern and interest to all members of this Institution. I feel that Mr. Parkinson's paper is most timely in drawing attention to the question and in throwing light on the great lack of facilities to suitably educate the production engineer in this country. Of the many difficulties to be surmounted I feel that the greatest is that of selection. We are all familiar with the old and still too popular method of selecting staff which scorns the use of modern aids and depends solely on the judgment of some individual. Many do develop a great facility and efficiency in this method, but even the best must admit that it can only produce somewhat inconsistent results. We must use every modern tool available to assist in this matter of selection as without the right material we cannot expect to produce a satisfactory article.

I suggest that the most prolific source of supply from which selection may be made will be those lads who are second or third-year apprentices or cadets and who have had time to look around and decide just what branch of engineering interests them most. To suggest that the average boy of sixteen or seventeen who wishes to become an engineer really knows what branch of the profession will suit him best or the type of work or position to which entry into such branch would eventually lead him is quite unacceptable to me. I think that the boy needs at least two years' practical experience before he is really competent to express an opinion and before others are competent to pass judgment in the way of selection.

A delay such as this would not, I think, cut across the proposals made by Mr. Parkinson and would be a definite safeguard in securing the desired results.

I do not presume to suggest actual methods of selection which might be applied to test the boy's aptitude or to determine the

suitability of his character, physique, home training and general education, but I do say that the question of selection is of fundamental importance.

Turning to the main body of Mr. Parkinson's paper I note that he has divided it under three main headings of general education, technical education and training. The standards and procedures which he suggests appeal to me, but I feel them to be of secondary importance to selection, and that the desired standard can only be obtained from boys whose home training has been suitable, whose general education has been wide and sound and who are scientifically selected after they have had general experience of the profession they desire to enter and that profession has had experience of them.

This question of education is all important and must be pursued vigorously, but while it is being relentlessly and scientifically pursued I sincerely hope that the elements of liberalism and the necessity for a broad outlook are not forgotten as without these the engineer cannot hope to occupy the position of eminence and respect which is enjoyed by other professions.

MR. PARKINSON: I think the point raised by Mr. Strick regarding the selection of boys at 16 or 17 years of age to become production engineers is one of importance. Very few boys at that age have any idea at all of what the various branches of engineering mean. In larger organisations this can be taken care of fairly readily by bringing all engineer trainees in for a period of two or even up to three years' general training before the final decision is made as to which branch of engineering they will follow.

It is possible in many of the larger organisations to plan a three-year training period to cover production engineers, mechanical engineers or electrical engineers and at the end of this period they have a reasonable appreciation of what the different branches in the organisation mean. During this training period they are, however, to be guided by talks from senior officers, outlining the possibilities of each of the three branches. One difficulty which may be encountered with a suggestion of this kind is that, at the end of the three-year training period all the engineers of that year may desire to go over to one branch of engineering and the other two branches left without their planned intake. However, this may never arise.

The matter of selection is one which cannot be stressed too strongly.

MR. MILLS: Mr. Mills said that he had been very interested and pleased to note that both Mr. Parkinson in his paper and the opening speakers had touched upon the human aspect of the training of engineers as apart from the technical aspect.

Before the commencement of any training a selection process was necessary. In the selection of young engineers attention should be

paid to physical as well as mental fitness. A certain amount of stamina is required by any boy desiring to enter upon a course of engineering training either at a technical college or a university. Much emphasis has been laid upon the strenuous nature of the technical college engineering courses. However, having had the experience of a university training he had to assure those present that the university engineering courses, at any rate in the Australian Universities, should not be regarded as any less strenuous than those associated with the technical colleges.

A youth having been selected for training, care should be taken of his physical well-being during training. Far too little attention is paid to this matter, not only in our engineering establishments, but also in our colleges and universities. In the case of the latter, a student in residence at a university college is in a very much better position than a student living outside the university itself.

The question of guidance is of particular importance in the case of apprentices and other trainees. It is very necessary that the industrial organisation employing a youth who is at the same time undergoing technical training should take a definite interest in the progress of that training. Several of the larger Australian engineering organisations do this, but others appear to have no interest in their trainees and apprentices other than the amount of work to be obtained from them. The Postmaster-General's Department has an excellent scheme whereby cadet engineers are required to write periodical reports upon the work they are doing. These reports are scrutinised by a senior officer of the department, who, if he thinks it necessary, arranges for extra coaching for trainees weak in a particular subject or subjects.

Having graduated either from a university or technical college, the graduate or diplomate should be given a post of some responsibility. Young men who have completed a course of training like to feel the weight of responsibility and become uneasy and dissatisfied if, having fitted themselves for senior work, they do not obtain what they consider to be their due share.

With regard to production engineering generally, the field is broad and indeed somewhat broader than had been indicated. Production engineers are engaged not only in the electrical and mechanical engineering industries, but also in mining, chemical manufacture, textile—and even the brewing industry.

Finally, the lack of university engineering graduates in the production field had been deplored. However, if the manufacturing industries desire degree men to enter this field they must devise a means of securing the services of young graduates in competition with other branches of industry and the professions. As matters now stand in Australia there are not sufficient graduates to fill all positions offering. Again, it had been suggested that a graduate

would have to undergo a further two or three years training before being fit to undertake responsible production management. In recent years most graduates have gone immediately upon graduation either straight from the universities or with only short periods of extra training into responsible positions with good salaries.

MR. PARKINSON: I agree with Mr. Mills' remarks regarding the human aspect of the training of engineers and also his comments regarding selection of young engineers.

The question of guidance is also one of particular importance and as pointed out in the paper, it should be the responsibility of a senior officer in any organisation to guide and assist young engineers during their training period. Reports furnished by the engineers assist considerably in giving the necessary guidance, but in addition to this, close personal contact should be maintained.

I am pleased that Mr. Mills dealt with the matter of responsibility, so few of the older engineers are prepared to pass on responsibilities quickly enough to young engineers and frequently this leads to a good deal of discontent and lack of interest on the part of these young men. After completing a course of training such as that outlined, they are ready for and should be given responsibility.

I agree with Mr. Mills regarding the broad field covered by production engineering. No reference was made in the paper to industries other than the electrical and mechanical, as I have no detailed information of them and felt that the discussion would take care of them.

It is difficult to attract graduates to production engineering, because as outlined by Mr. Mills, there are at present so many avenues of employment opened to them in positions of responsibility with good salaries immediately after graduation. However, this does not alter my opinion that if they are to take their place in the manufacturing industries, it is essential that after graduation they should have a further period of training of up to two and a half years before they can be usefully employed in production engineering. This difficulty may be overcome if the larger industries in Australia follow the practice of some of the larger engineering organisations of Great Britain, where youths are employed after matriculation for a period of twelve months in their workshops and then sent to universities for technical training. In this way they are sure of getting the graduates they require.

MR. CLARKE: Had Mr. Parkinson given due consideration to the great advantages to be had in the training of production engineers by sending them overseas to study in some of the more advanced workshops? In my opinion, this course should follow the completion of their local training and schooling.

In Australia, of necessity, we have certain limitations (due to our

population, etc.), and in order to produce at a competitive figure we must lead in methods of manufacture, and to do this we must know what the overseas man is doing so that we may aim even higher still.

MR. PARKINSON: I feel that such a scheme as outlined by Mr. Clarke would produce very excellent results. Some organisations in Australia do arrange for their engineers to receive training overseas, but in such cases they usually have some tie up with an overseas organisation permitting this sort of thing to be done. Those not having similar arrangements will find great difficulty in making the necessary arrangements. However, it may be possible to make some arrangement of this kind through the Institution in England.

MR. DENNING: I desire to congratulate Mr. Parkinson on the excellent survey that he has made of the education of the production engineers. He has shown that there are a number of factors which must be considered to produce not only a sound production engineer, but a desirable citizen. The responsibility also must be placed on more shoulders than previously has been the case.

Besides the student, the employers, vocational guidance officer, the technical teacher, the parent and such institutions as the Institution of Production Engineers, must all play their part.

There is one matter that I should like to comment about particularly, and that is the question of wastage. Mr. Parkinson has discussed wastage at the Technical College. Members probably feel that such wastage is abnormal. However, the figures generally on wastage in tertiary institutions is quite high.

I can recall that in two different university years, in one case fifty-two commenced and thirteen graduated, in the normal period and in another case thirty-three commenced and seven completed the course in the normal time. The figures quoted by Mr. Parkinson were made as a result of an analysis of certain groups of diploma students who commenced their studies in 1937 and 1938.

In 1941 a survey was made as to the progress that had been achieved by all students. It is admitted that these figures might be unduly low because of the inroads made by war conditions—excessive overtime and enlistments being the chief ones acting in this direction.

In addition, intelligence tests are administered to all diploma students on the commencement of their course. This, together with the survey, suggests that many of our students undertake or aspire to undertake diploma courses who are not intellectually equipped to do so.

It must not be overlooked, however, that some students, sufficiently endowed to complete their course, do not in fact do so. Temperament (interest and persistence), unfavourable environment (home and working conditions), and the belief that the course is not meeting

their needs, would seem probable ones. The fatigue induced by full-time work in the day and part-time evening studies is an order that demands a high degree of persistence and ambition if the final goal of the diploma is to be achieved.

The Sydney Technical College this year has inaugurated the post-diploma course in production engineering. We realise that this course must be modified in the light of experience, but this is a start in the right direction. The Institution of Production Engineers is to be congratulated on their enthusiastic co-operation with the Technical College in the establishment of the course.

MR. PARKINSON : Thank you.

ELECTRIC FURNACE BRAZING

Paper presented to the Institution, Luton and Bedford Section, on Sunday, 28th January, 1945, by George P. Tinker, M.Sc. (Assistant General Manager, Birlec Ltd.), at Luton.

General.

THE fabrication of metal assemblies can be carried out by a number of well-known methods, such as torch and dip brazing, soft soldering, riveting, pinning, welding, etc., and during the past few years, electric furnace brazing has established for itself a very definite place in this sphere of manufacture. Its consistent results, simplicity of operation, great strength of joint, rapid production and cleanliness have resulted in its adoption by many manufacturers.

Repetition parts previously produced by one of the methods referred to above or by casting, forging, or machining from the solid have been furnace brazed with every satisfaction.

Foremost among the advantages gained are the economies which can be effected in materials, machine and man hours and especially in skilled labour, resulting in practically every instance, in a reduction in cost of the product.

It should be stated at once, however, that there is no claim that electric furnace brazing will supplant every modern method of fabrication, but it does offer to suitable industries a new technique of manufacture and gives benefits obtainable in no other way.

It is the purpose of this paper to deal chiefly with the copper brazing of low carbon steels and to give a brief description of the process, reviewing various applications where furnace brazing has been successful.

Process.

In the electric furnace brazing process, assemblies are made up with the brazing medium, in some such form as wire, applied near to the joint to be brazed. The assemblies are then passed through an electric furnace in which a neutral or reducing atmosphere is provided. This special atmosphere chemically cleans the surfaces of the metals, preventing oxidation or actually reducing any oxide already present and prepares the surfaces for proper wetting by the molten brazing material. When the brazing material melts it is drawn by capillary attraction into the joint and alloys with the parent metal, producing joints of great strength. The work is then transferred into an adjoining controlled atmosphere cooling chamber, where it is retained until it has cooled to a temperature at which it can be discharged into the outside air without danger of discolouration due to oxidation. Many references will be made to the use of

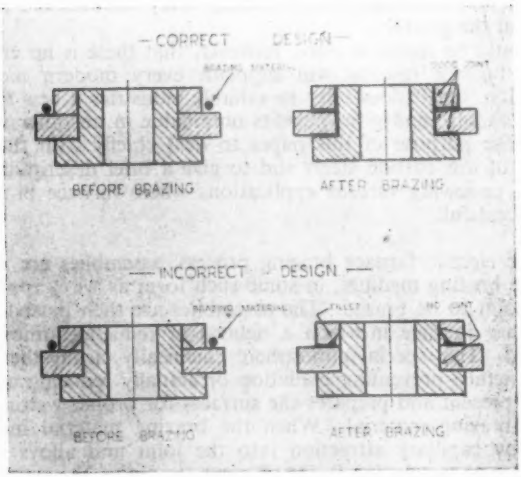
copper as the brazing medium when dealing with steel assemblies. Undoubtedly, the combination of copper and steel is the most common one, although other brazing mediums and parent metals are sometimes used.

It can be mentioned that the equipment used for brazing is also suitable for bright annealing and may be installed for both purposes when the quantity of brazing work to be dealt with will not keep the furnace fully occupied.

Assembly of Parts.

The method of holding the assemblies together, the design of the joint and the means of applying the brazing metal are all closely related and the success of furnace brazing depends very largely upon these fundamentals. The methods of assembly which are adequate for hand-fabricated parts do not necessarily apply when furnace brazing is to be considered. A composite joint of the type illustrated will explain this point.

" A " shows an assembly with snug metal to metal joints throughout, with square close-fitting corners leaving no gaps. The brazing metal will flow evenly through these joints and will give an excellent bond.



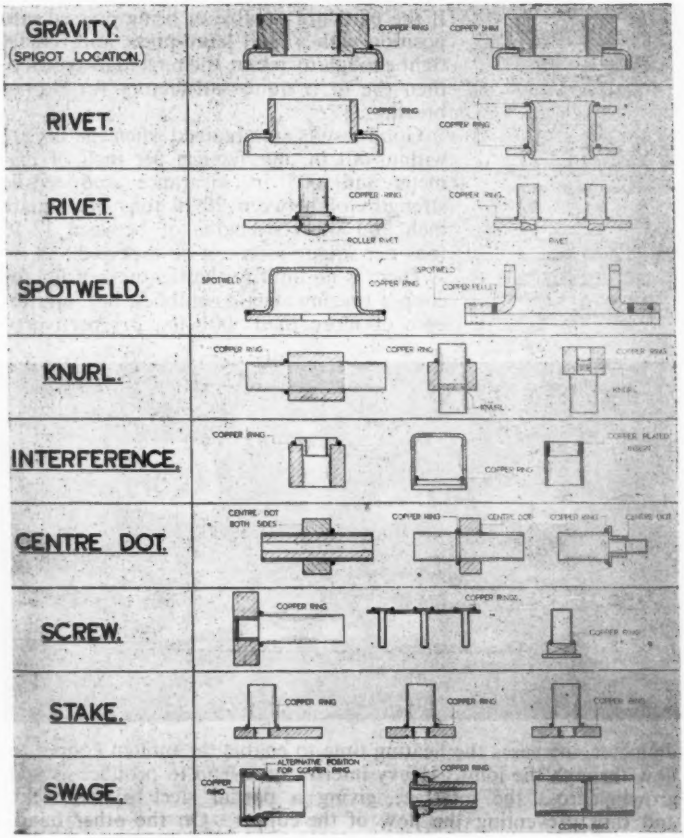
" B " shows the same assembly, but with a chamfer on the underside of the collar which has broken up the capillary path and prevented the copper from flowing into the rest of the joint. Rounded

edges due to worn or blunt tools will contribute to the fault, or a chamfer may have been provided to facilitate assembly.

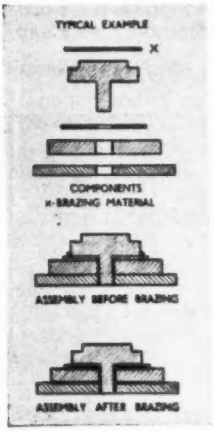
The location of the parts may be done in a variety of ways, depending on the shape of the assemblies, and may be one or a combination of the following methods : pressing the parts together ;

COPPER BRAZING.

METHODS OF LOCATION.



spot welding ; swaging ; expanding ; peening or staking ; riveting ; holding parts with screws or pegs. The use of jigs should be discouraged as they tend to impair the efficiency of the furnace. Their extra weight will slow down production and unless their construction is robust, distortion or warping will take place.



By far the best and most common method of assembling is by pressing the parts together ; in this way the best capillary field is produced and every effort should be made to provide a snug fit at all times if maximum strength and tightness in the joint are required. If the parts are capable of being pressed into position with a light hand-press, and remain tight enough to retain their relative position, then the fit is quite satisfactory for copper brazing.

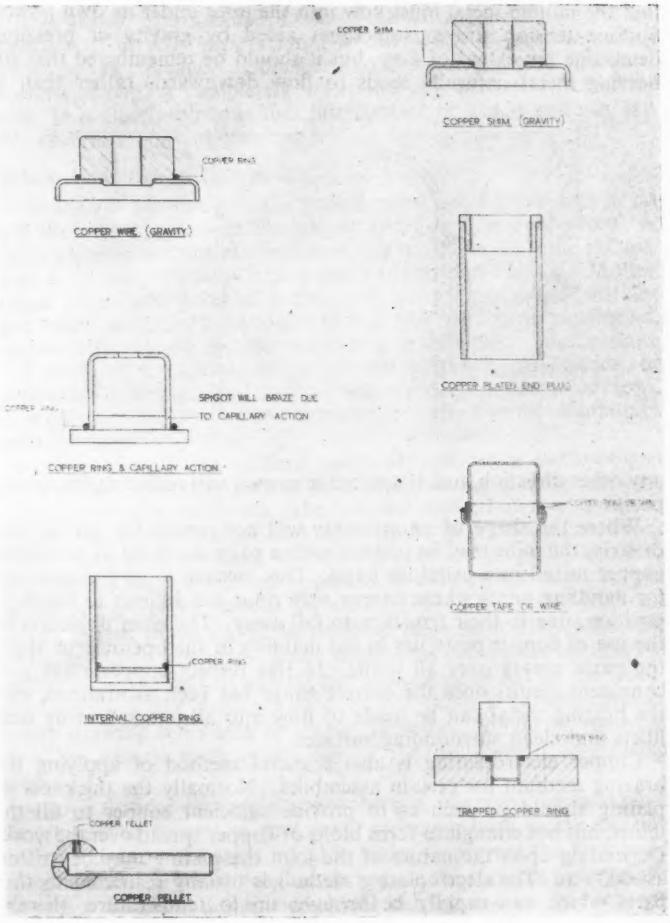
Good results are obtained when the fits are within ·001 in. interference per inch of diameter and ·003 in. clearance and tensile strengths of between 20/24 tons per square inch and shear strengths of between 12/16 tons per square inch can be expected.

There is no limit to the tightness of fits for copper brazing steel assemblies, but interference of more than ·001 in., irrespective of

diameter, increases the heating time to enable the molten copper to flow through the joint. Heavy interferences tend to produce crystal growth across the interface, giving a partial steel to steel weld, and thus preventing the flow of the copper. On the other hand,

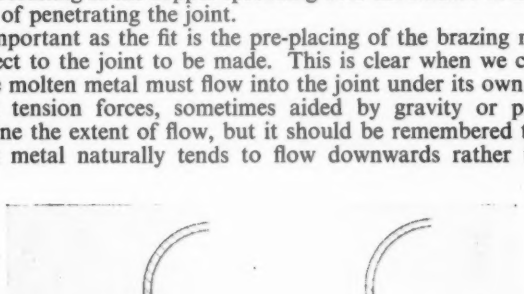
COPPER BRAZING.

METHODS OF INTRODUCING COPPER.



clearances exceeding ·003 in. give a weakened joint, approaching that of annealed copper, the capillary action being seriously impaired, resulting in the copper spreading over the surface of the work instead of penetrating the joint.

As important as the fit is the pre-placing of the brazing medium in respect to the joint to be made. This is clear when we consider that the molten metal must flow into the joint under its own power. Surface tension forces, sometimes aided by gravity or pressure, determine the extent of flow, but it should be remembered that the brazing metal naturally tends to flow downwards rather than in



any other direction and, if applied in excess, will collect at the lowest position.

Where the shape of an assembly will not permit the use of wire or strip, the joint may be painted with a paste made up of powdered copper mixed in a cellulose bond. This method is very convenient for handling joints where copper wire rings are difficult to retain in position, due to their tendency to fall away. The chief objection to the use of copper paste lies in the inability of the operator to apply the paste evenly over all joints. In this respect copper rings give consistent results once the correct gauge has been ascertained, and the brazing metal can be made to flow into all joints, leaving neat fillets and clean surrounding surfaces.

Copper electroplating is also a useful method of applying the brazing medium for certain assemblies. Normally the thickness of plating should be such as to provide sufficient copper to fill the joints, but not enough to form blobs or copper spread over the work. Depending upon the nature of the joint the plating may be as thin as ·0005 in. The electroplating method is usually restricted to thin parts which can rapidly be brought up to temperature, thereby preventing the thin copper film from being absorbed by the parent metal.

Design of Joint.

Capillary attraction plays an important part in the furnace brazing process and various features which affect it must be considered.

It has already been pointed out that joint clearances in excess of ·003 in. will affect the flow of copper and all joints, therefore, should be close fitting. The distance of flow of the brazing metal by capillary attraction is directly proportional to the width of gap, becoming greater as the clearance diminishes and decreasing as the clearance increases, stopping completely when the gap becomes excessively wide. It is clearly obvious that line contact or a non-uniform gap will result in a non-uniform bond.

Surface Condition of Assemblies.

The surface condition of the parent metal has a great deal to do with the wetting action of the copper and its tendency to creep. A highly polished surface, for instance, will not have the same inducement to "copper creep" as a clean roughened surface. Molten copper on a clean polished surface will wet the metal, but will not have much tendency to spread. Should the surface be roughened, however, the copper will spread out in a thin film and distribute itself evenly. A pickled, rough ground or machined surface, or particularly a shot-blasted surface will present the best conditions, since pores, small grooves and scratches provide a series of capillary paths for the fluid to creep in.

Surfaces of a rusty or oxidized nature are reduced by the hydrogen in the protective atmosphere at the copper brazing temperature into a spongy white matte finish. The reduced oxide, however, tends to impede the capillary flow and may result in an irregular bond. Whilst steels with oxidized or rusty surfaces are generally avoided, they can be brazed with no apparent ill effects, but extra copper should be applied to provide for absorption by the matte surfaces.

Dirt, grease, or oil should be removed prior to brazing if the best results are to be obtained. These extraneous substances impede the wetting action, although thin oil can sometimes be left on the work, provided it distills readily and does not leave a carbon deposit. Heavy drawing lubricants or grease, therefore, should be removed by a hot caustic wash or by one of the well-known de-greasing agents.

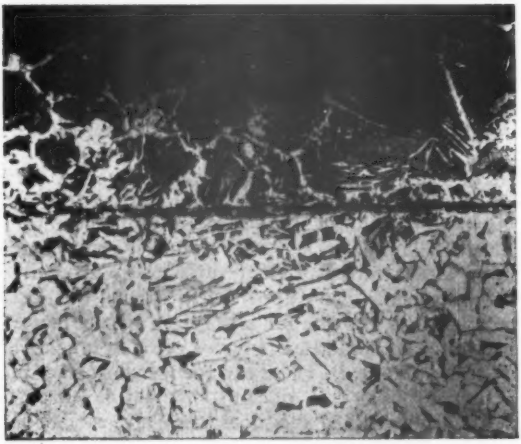
A good furnace protective atmosphere is, of course, essential and this should be neutral or preferably reducing, both to the brazing material and to the parent metal in order to prevent the formation of oxide films. If the atmosphere is impure the surfaces to be joined become oxidized and the copper will ball up and no wetting will take place.

The effects of furnace temperature and heating time are also important on the wetting action of the copper.

As both the temperature and the time in the heat are increased so will the wetting action be improved and the tendency for the copper to creep be increased. In general practice, the furnace temperature is set at approximately 1120°C. and the time in the furnace is kept at a minimum consistent with good quality.

Strength and Effects on Structure.

One of the outstanding features of the process is its ability to produce joints of great strength, and it is not uncommon to find that a properly designed joint will have a higher strength than the mild steel parts composing the assembly. The actual strength depends largely on the clearance between the mating surfaces. If the joint is a comparatively tight fit, interfusion of the iron and copper takes place with the formation of a copper-iron alloy, leaving no free copper film at all. This alloying, coupled with the "growing



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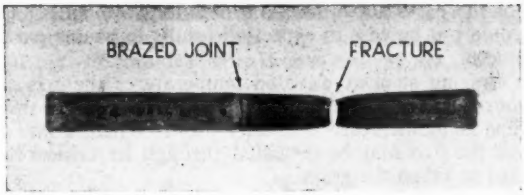
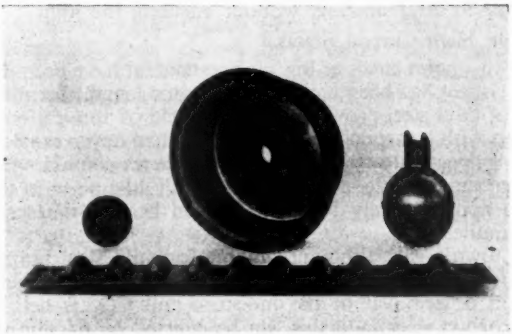
together effect" of the mating surfaces accounts for the strength of the furnace-brazed joint.

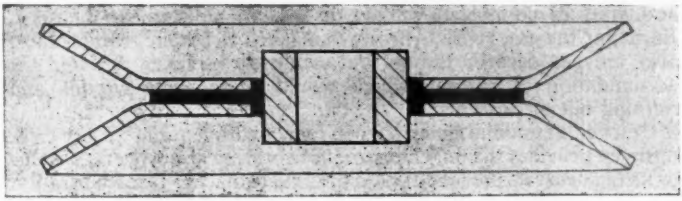
A tensile test piece, comprising two strips of mild steel with a butt-brazed joint, was pulled in a tensile testing machine and broke at a part remote from the joint at an ultimate stress of 24 tons per square inch.

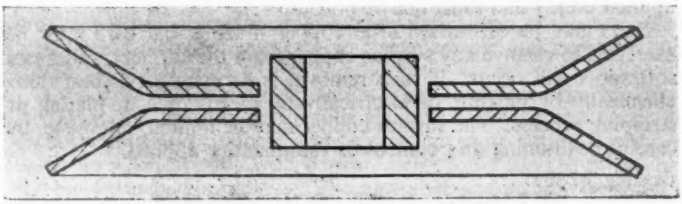
When brazing on a production basis it cannot be expected that





Examples of Copper Brazed Components





Fabricated Fan Pulley before and after brazing

the fits of the parts and other considerations are consistently ideal and it would not be wise to expect all results to be comparable with the test piece.

When brazing steel at elevated temperatures there is some enlargement of the grain size, but normally this is of little consequence, as the time at temperature is usually short. Where a fine structure is required the part may be re-heated through its critical range and normalized to refine the grain.

In cases where the annealed structure is detrimental, the parts may be subjected to a heat treatment process or may be hardened or carburised after brazing, without affecting the joint.

Effects on High Carbon Steels.

Up to this point steels of low carbon content have been dealt with and this aspect has been considered at some length, because copper brazing of mild steel provides its widest field of application.

If steels with a carbon content of more than approximately ·3 per cent. are subjected to treatment in atmospheres containing moisture and/or carbon dioxide decarburisation will take place to the extent of up to approximately 10 thou. deep in heating times of five to fifteen minutes.

Burnt town's gas, although suitable for mild steel brazing, contains moisture and CO_2, both of which are active decarburisers. Reduction or removal of the moisture and CO_2 is helpful when brazing carbon steels and this can be effected by passing the gases through an activated alumina or silica-gel dryer and CO_2 stripper. The furnace must be so designed as to minimize the infiltration of air and must be completely purged of air and moisture at the start. Enriching the gases with hydro-carbon (such as butane, for instance) also reduces decarburisation, but care must be taken to avoid the accumulation of carbon, which would cause short circuits and burning out of elements.

Cracked ammonia giving 75 per cent. hydrogen and 25 per cent. nitrogen provides the only moisture-free brazing atmosphere, but due to its high cost its use is restricted to small furnaces. Decarburisation can be largely prevented by copper plating high carbon steel parts to a minimum depth of ·0005 in. The plating must, however, be applied evenly and must not be porous.

Parts may be carburised after copper brazing, but care must be exercised to remove any surplus copper from the surfaces, otherwise soft spots will occur. If such removal is necessary it is best done chemically by pickling or electrically by means of a de-plating or stripping process. The surplus copper may be limited, of course, by careful positioning and control of the quantity applied.

Brazing Media.

It is possible to furnace-braze practically any ferrous or non-ferrous

metals, provided the choice of atmosphere, brazing medium and flux, where necessary, is correct. The most commonly used brazing media at present employed for furnace-brazing are :—

1. Copper, which melts at 1080°C.
2. Brass, „ „ „ 890/950°C.
3. Sil-Fos, „ „ „ 705°C.
4. Easi-Flo, „ „ „ 630°C.

Copper.—Copper is used wherever possible as the brazing medium, because of its easy wetting and free flowing action, coupled with cleanliness and strength of joint. Flux is not necessary when copper-brazing ordinary steels because the parts become chemically clean in the furnace, but a flux may be necessary to remove the oxides formed by such constituents as chromium, manganese, aluminium, vanadium, silicon or zinc. As a general rule, a flux may be required when these constituents total more than one or two per cent. of the parent metal. Flux is naturally avoided whenever possible, as it is messy to apply and difficult to clean off after brazing. It might be mentioned that nickel is a helpful constituent, as, owing to its affinity for copper, it encourages the wetting action.

Brass.—Brass, which has a lower melting point than copper, is sometimes used, but usually a flux is required to ease the flow. If the brass can be embedded in the joint a flux is not always necessary.

Sil-Fos and *Easi-Flo.*—Sil-Fos, an alloy of copper, silver and phosphorous, and Easi-Flo, an alloy of copper, silver, zinc and cadmium, are used largely for the lower temperature brazing of non-ferrous metals, such as copper, brass and bronze.

Metals which can be Brazed.

The furnace brazing of non-ferrous metals, alloy and special steels is not quite so straightforward as that of low and medium carbon steels and, before sanctioning the furnace-brazing of any of these metals the production engineer will be well advised to consult a metallurgist familiar with the process. Non-ferrous metals may need very careful control of time and temperature, due to the rather high rate of diffusion of the brazing alloy into the metal. Where the brazing assemblies contain zinc, some volatilisation of the zinc takes place which increases with time and temperature and rapid heating is, therefore, desirable.

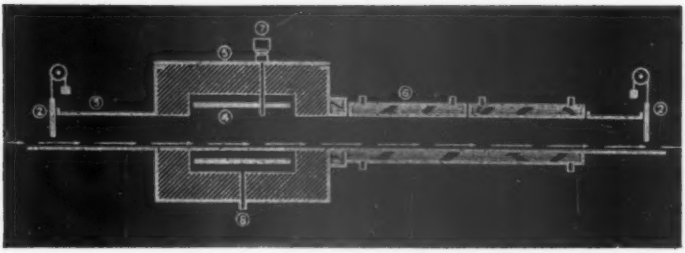
A cracked ammonia atmosphere is most suitable for brazing non-ferrous metals and the best results are obtained when the parts are of fairly thin and uniform section. Whilst close fitting joints are desirable when brazing with copper, fairly loose fits are preferable for the silver-brazing alloys. The clearance should not be smaller than ·001 in. and gaps of ·002 in. will give the best results.

Copper is subject to a phenomenon known as "gassing" or embrittlement when treated in a reducing atmosphere and, when brazing assemblies made of copper, consideration should be given to the type of copper used. Such embrittlement can be limited either by specifying oxygen-free copper or by brazing in a neutral atmosphere.

Types of Electric Brazing Furnaces.

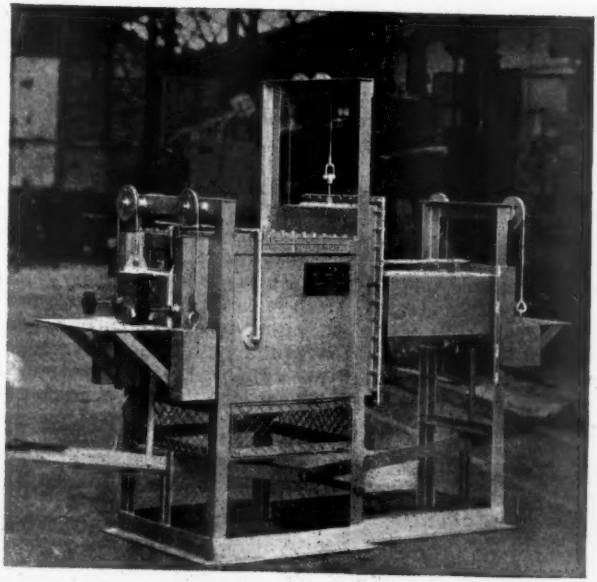
The most usual types of brazing furnaces are the batch or semi-continuous, the mesh belt conveyor and the pusher and roller hearth types, and the choice of furnace to be used for any particular purpose depends upon a number of factors including weight, shape and size of the assemblies to be brazed, rate of production, cost of operation and maintenance and permissible outlay.

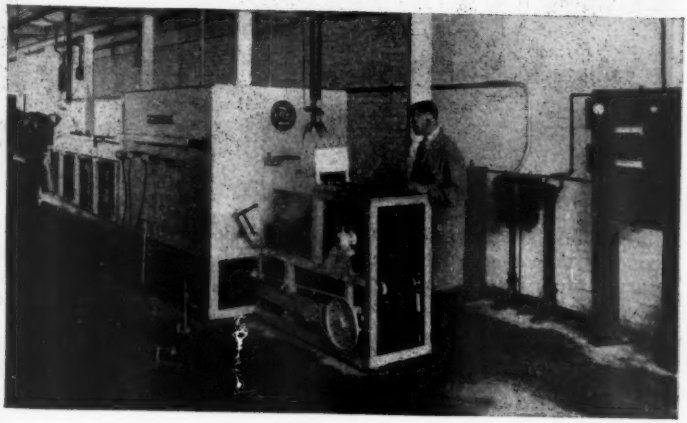
Semi-continuous Type.—The simplest and cheapest arrangement is the batch or semi-continous furnace, which consists of an electrically-heated chamber interconnected with a water-jacketed cooling chamber. There is a door at each end of the furnace and, in some



cases, a door between the heating and cooling sections. The whole installation is made gas tight and is provided with gas inlet and outlet pipes, the work being pushed through the furnace and cooling chamber intermittently in trays. This type of furnace is very convenient for a small output of varied parts, light, medium or heavy, and is often used for experimental and development work. Owing to its usual small size and limited gas requirements it is usually provided with an atmosphere of cracked ammonia.

Mesh Belt Conveyor.—The mesh belt conveyor type brazing furnace, which is most popular and convenient for general miscellaneous work of relatively light weight, is similar to the semi-continuous type, but, in addition, is provided with a continuous conveyor belt of the wire-mesh pattern, made of nickel chromium alloy. The work is generally loaded direct on the belt and the drive mechanism is usually arranged to give a speed variation of 6 : 1, in



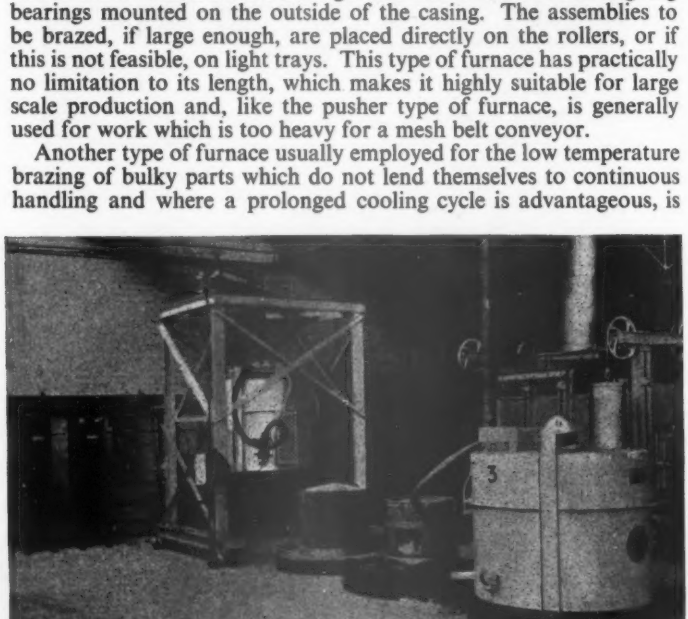


order that assemblies of widely different heating rates can be dealt with. The process is continuous and, as the time in the furnace and the temperature can be pre-set, consistent results are obtained.

Pusher and Roller Hearth Types.—The pusher type of furnace transports the charge, which is carried on substantial alloy trays or baskets, through the heating and cooling chambers by means of an external pusher gear.

In the roller hearth furnace the conveyor consists of a series of driven rollers which extend through the furnace walls to self-aligning bearings mounted on the outside of the casing. The assemblies to be brazed, if large enough, are placed directly on the rollers, or if this is not feasible, on light trays. This type of furnace has practically no limitation to its length, which makes it highly suitable for large scale production and, like the pusher type of furnace, is generally used for work which is too heavy for a mesh belt conveyor.

Another type of furnace usually employed for the low temperature brazing of bulky parts which do not lend themselves to continuous handling and where a prolonged cooling cycle is advantageous, is



the lift-off bell furnace. The charge is placed on a hearth and covered with a gas-tight sheet metal hood or bell. The hood is purged of air by suitable gases and the furnace is placed over it, the heating being kept on for a sufficient length of time to heat up the whole mass.

Since the charge can be heated up more rapidly than it can be cooled, several hearths are generally installed, each being loaded, heated, cooled and unloaded in sequence.

Another method of heating, which does not really come within the scope of this paper, has recently been applied to copper brazing, namely, high frequency heating.

In this process, a high frequency current from a valve, spark gap or motor generator is passed through a water-cooled inductor coil and eddy currents are induced in the parts to be heated and brazed. The joining material is located much as it is in furnace-brazing and a controlled atmosphere can be used by enclosing the work in a pyrex or silica tube.

In some instances a flux is used in place of the controlled atmosphere.

The high frequency equipment is mainly suitable for repetition brazing of small parts—not large bulky articles—and its main features are compactness and rapidity of heating, whilst it is especially adapted to localized brazing where only a small portion of the component need be heated. In this manner the physical structure of the metal (apart from that heated locally for brazing) is unaffected.

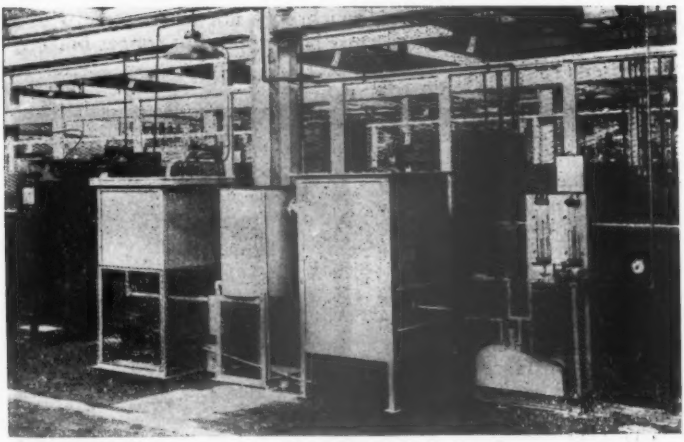
Controlled Atmospheres.

As stated previously, a neutral or reducing atmosphere is an essential feature of the furnace-brazing process and this atmosphere is usually derived either from the partial combustion of town's gas or the dissociation of ammonia.

Town's gas is by far the more widely employed, since it is a convenient source of supply, is cheap and the processed gas will give perfectly bright results on nickel alloys and steels.

While atmosphere generators using town's gas differ in detail, the principle is the same in each case. Controlled quantities of gas and air are mixed and are burnt in a brick-lined combustion chamber and the products of combustion are then passed through cooling towers in which the bulk of the water vapour is condensed out and then through a bog ore chamber to remove sulphur.

The processed gas consists of approximately 10/13 per cent. hydrogen, 8/10 per cent. CO, 6/6·5 per cent. CO_2—remainder nitrogen with a small percentage of water and under 1 per cent. methane.



After passing through the furnace the gas is led away through ducting to prevent pollution of the atmosphere of the workshop. The cost of the atmosphere produced in this way is approximately one-third of the cost of the original town's gas, due to the increased volume brought about by the introduction of air for combustion.

Where small volumes of extremely pure gas are required, either cracked or burnt ammonia is used, but the operating costs for gas are considerably higher than when using town's gas.

In the cracker plant, which is electrically heated and thermostatically controlled, the ammonia is dissociated into its constituent elements, hydrogen and nitrogen in the proportion of 75 per cent. hydrogen and 25 per cent. nitrogen. The cost of this gas, which because of its purity and dryness is ideal for the treatment of most metals, varies from 15/– to 20/– per thousand cubic feet according to the size of the container in which the ammonia is purchased.

If cracked ammonia is partially burnt with a controlled amount of air, a non-explosive gas is obtained, containing up to approximately 10 per cent. of free hydrogen—the remainder nitrogen. After burning, the gas is first cooled to condense most of the water vapour and is afterwards dried and then passed to the furnace. The cost of burnt ammonia is roughly half the cost of cracker gas, *i.e.*, approximately 7/6 to 10/– per thousand cubic feet. It is obvious that under these conditions cracked or burnt ammonia, despite their manifold advantages, would be used only on small-scale work or where other atmospheres were quite unsuitable.

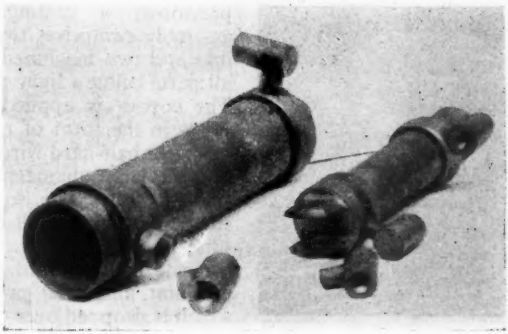
A more recent method of using burnt ammonia has been intro-

duced which brings the cost down to approximately 1/– per thousand cubic feet supplied to the furnace, that is, to roughly the same price as an atmosphere derived from town's gas. With this system, the gas generator, *i.e.*, the ammonia burner, and the furnace form a closed circuit in which the gases, after they have passed through the furnace, are returned to the burner for purification and testing of analysis. A 10 per cent. make-up of freshly cracked and burnt ammonia is usually sufficient to maintain an effective atmosphere inside the furnace and this system is finding wide application with bell furnace installations. In the case of a continuous furnace, however, special precautions have to be taken at the inlet and outlet of the furnace and ammonia is not normally recommended for this application.

Applications.

A number of interesting parts which are now being produced by furnace-brazing will be described.

One aircraft firm has changed over completely to furnace-brazed



hydraulic jacks, with a subsequent saving in time of 50 per cent. and a saving in material of 59 per cent. An article by Mr. D. H. Smith, M.I.A.E., published in the September 1943 issue of "Aircraft Production" and entitled "Furnace-Brazing" gives interesting data on the economics of the process. Quoting from the article :—

> "One control jack, fitted to a well-known type of bomber, is produced in large numbers by copper brazing, and a comparison of machining times involved in the former method of production from the thick walled tube, and the present brazing technique shows a saving of over 50 per cent. Tube boring, thread milling, welding, internal roughing, and much of the precision grinding is eliminated, while centre lathe operations are reduced to one-

eighth. Some additional sensitive drilling is involved, and there is, of course, the brazing operation, but these only amount to about 4 per cent. of the total production time, so that the overall saving is in the region of 47 per cent. Assembly times have been ignored, but had they been taken into consideration the final figure would be even more favourable."

The brazed method considerably simplifies the cylinder and eliminates a pressure joint ring, thread milling on the end, fitting a screwed sleeve, a split ring, and grub screws, as well as dispensing with welding for the pipe connector. The production man hours per set of five jacks is 12 hours 40 minutes, as against 25 hours 31 minutes by the former method. After brazing, the jacks have to withstand a test pressure of 3,000 lbs./sq. inch ; the working pressure being 1,200 lbs./sq. inch. R.A.E. tests have proved that these brazed jacks will withstand up to 9,000 lbs. per square inch pressure or three times the normal test requirements.

An example using copper rings is shown in the fabricated oil or air filter body, which was previously a casting. The assembly comprises two pressings and two machined bosses, all parts being a light press fit. The copper is applied to the joints in the form of rings, an 18 gauge half-hard wire is used on the large diameter, made slightly under size so that it springs into the small recess, a small copper 20 gauge ring on the side boss, located close to the joint, and a 20 gauge ring which is dropped over the locating shoulder on the top boss. The whole assembly is inverted to ensure that the top boss retains its position, it being held in place by its own weight, so that direct capillary attraction is induced in the joint between the pressings. The assembly is placed on the furnace belt in the inverted position on small nickel chromium rings. The rings are made from old burnt-out heating elements, and although useless as elements, have done service as jigs for some eighteen months.

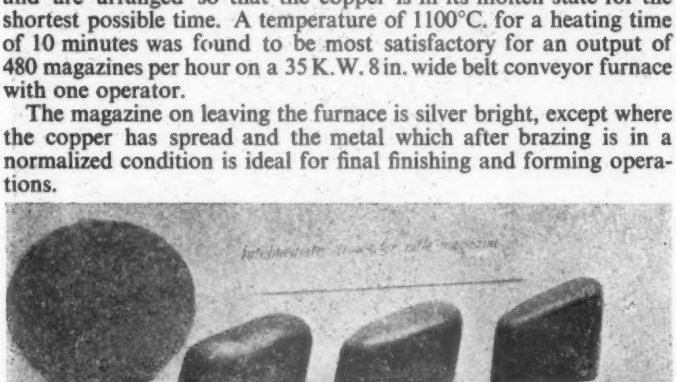
The use of copper strip as a brazing medium is well illustrated in the rifle magazine and tubular magazine, both of which involve the vertical butt jointing of thin material. Vertical seams are difficult to braze because the copper flows downwards due to the force of gravity, and tends to leave the joint. Careful control of the furnace temperature and heating time is most essential and it is important that the joints are a square butt fit.

The rifle magazine is made up of right and left-hand shallow draw pressings, the joining edges being sheared square and to size. The pressings are then assembled in a jig and the two halves are spot welded together at three points along the joint. The spot weld on the bottom of the long end of the magazine also fixes the magazine lug. The brazing material, in the form of copper strip $\frac{3}{32}$ in. wide and ·003 in. thick is then lightly spot welded over the joint at two points. The length, position and section of the strip are of great importance in this instance, since it is desired to braze the assembly without blobbing of copper on the two ears at the bottom of the short end of the magazine. The magazine lug must also be brazed-on at the same time as the butt joint.

It has already been stated that molten copper will flow freely downwards, and this gravitational effect is taken into account when positioning the strip on the magazine. The copper in its molten state runs into the joint at the top sloping surface, and is retained there by capillary attraction. At the same time excess copper flows downwards through the two vertical joints and fulfils the requirements of the job by brazing the assembly neatly, and entirely free from blobbing.

The temperature and the time in the heating chamber are critical, and are arranged so that the copper is in its molten state for the shortest possible time. A temperature of 1100°C. for a heating time of 10 minutes was found to be most satisfactory for an output of 480 magazines per hour on a 35 K.W. 8 in. wide belt conveyor furnace with one operator.

The magazine on leaving the furnace is silver bright, except where the copper has spread and the metal which after brazing is in a normalized condition is ideal for final finishing and forming operations.



In contrast to this method of manufacture is the previously-practised deep drawing method, which requires seven or eight drawing operations with an annealing operation before each subsequent draw. As compared with the one drawing operaton and one furnace operation of the brazed magazine, the deep drawn type requires seven or eight times as long to make, besides involving considerably more labour.

The tubular magazine comprises a perforated plate, which is formed into a tube, and a screwed head. The butt joint and the head are required to be brazed, the head portion is grooved for the copper ring to ensure

correct location of the wire, and the butt joint on the tube is spot welded at three or four points to ensure a close fitting joint.

A copper strip ⅛ in. wide by ·004 in. thick is spot welded over the joint at one point, and is bent over the edge of the tube. The screwed head is made a clearance fit in the tube so that there will be no possibility of the butt joint bursting due to differential expansion.

The whole assembly is placed on the furnace belt in an inverted position, being supported on small nickel chromium rings. The extra copper at the extremity of the tube provides sufficient surplus material to balance the rapid flow downwards, and all excess copper flows into the head of the magazine and forms neat fillets on the inside. On a 35 KW 8 in. wide belt conveyor furnace the output is 600 per hour.

Operating Costs.

The following typical costs refer to a 35 KW, 8 in. wide, belt conveyor electric furnace dealing with 100 lbs. of steel parts per hour, with a combusted coal gas atmosphere.

	s.	*d.*
Power cost per hour at 0·5d. per KW.h.	1	0
Atmosphere cost per hour with town gas at 2s. 6d. per 1,000 cu. ft.		8
Maintenance cost per hour		9
Labour cost per hour (two girls)	2	0
Total operating cost per hour	4	5

Fabrication cost per pound of work brazed, approximately 0·5d.

Conclusion.

It has been possible in this single paper to deal only with the subject of electric furnace-brazing in a general way and only its salient features have been touched upon. Undoubtedly, the process is rapidly gaining favour in this country and it seems certain it will make further progress in the future, replacing many of the costly, cumbersome and old-fashioned methods which are at present in use. The art is relatively simple, easy to use in production and one which the production engineer will take in his stride. He will find that he can successfully incorporate his own ideas into the design or re-design of a product, which can then be furnace-brazed at a fraction of its previous cost.

DISCUSSION.

CHAIRMAN: I am sure we have had a very interesting paper by Mr. Tinker. The meeting is now open for discussion and Mr. Tinker will endeavour to answer any questions you may like to put to him.

MR. BUCKLEY: Unfortunately, I was unable to be here at the commencement and missed the early part of Mr. Tinker's lecture. This process is one in which I am very interested and I think electric furnace brazing has a great future. To me it seems to have one snag on non-ferrous material, that is, the excessive annealing with consequent loss of strength. As I was entering the room Mr. Tinker was talking about high frequency brazing, and I would like him to tell us if it is possible to braze such things as nickel and ordinary brasses without excessive annealing.

MR. TINKER: I am afraid high frequency brazing is very much in the elementary stage. When you deal with non-ferrous assemblies the brazing temperature is considerably reduced by using silver alloys. The question of excessive annealing is largely eliminated by this. There is no reason why it should not be so good on brasses, but you would require to use flux. I certainly think it could be applied to non-ferrous alloys.

MR. WALKER: There are one or two points I would like to raise. One is tests. Have you tried any tests on rough turned finishes against smooth finishes with same components?

Would not a slight chamfer be an advantage where you were brazing that component into tube (I am referring to the one you show on the film), and also, how would you stop your brazing running along the face of the flange where you have ·002 to ·003 in. fit, the fit across face of flange where you require brazing?

MR. TINKER: I regret I have no figures of a test as between rough and smooth finish. We have found the rough finish gives much the better braze, and I should expect the rough finish to give the greater strength. Smooth finish does prevent wetting, it is really remarkable, you would expect it the other way round. Shot blasted finish face is very good. A rough machine finish gives very good results and I should expect very great strength provided the clearance is correct.

Chamfering. Sharp corners give a better result, because if you have a chamfer the copper tends to flow into it, rather than through the joint, since the chamfer breaks up the capillary path. The tighter the fit, the squarer the corners, the better the job. As regards brazing running over finish I am not quite clear what you have in mind, but if you will let me have a sketch showing what you have in mind, I will endeavour to explain.

MR. WALKER: I was thinking the face would have to be square in the horizontal position. There would be a tendency to run down the hole and across the face of the flange instead of going into the slot.

MR. TINKER: Gravity does help. If the joint is a tight fit it will run into the joint. If you will kindly give me a sketch after the meeting I will try and explain.

MR. PENNINGTON: Can this method of brazing be done on high carbon as well as on low carbon steel, having in mind case hardening. On high carbon steel it would tend to soften the copper—that would weaken the joint.

MR. TINKER. You have to be prepared for some de-carburization on the surface, it may be as much as ·010 in. on 8% carbon steel. In cases where finishing operations are carried out after brazing, a sufficient grinding tolerance is allowed to remove the soft skin. Should you count on a low grinding tolerance or where no further operations are undertaken, the usual method is to copper plate the whole of the assembly. With regard to copper spread on surfaces which have to be carburized subsequently, the copper will have to be removed. Little harm is done to the joint itself unless the component is allowed to remain in the stripping bath for an unduly long period. With correct fits and allowing only sufficient copper to fill the joint, copper spread may be almost entirely prevented.

CHAIRMAN: Can you tell me what the comparative reduction in cost was from using the eight methods of drawing down the magazines, as against the butt welded method which has been adopted.

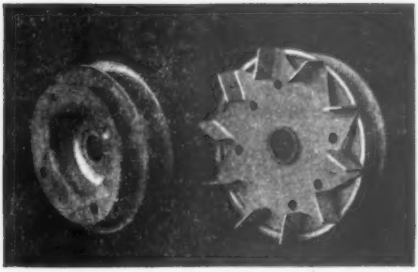
MR. TINKER: No. The different methods were done by two different firms, but the time saving was enormous. We were doing the copper brazing and annealing for the two firms.

CHAIRMAN: If there are no further questions, I would like to ask Mr. Bullock to propose a vote of thanks on our behalf to Mr. Tinker.

MR. BULLOCK: It is a pleasure, gentlemen, which has fallen on me rather suddenly to propose a vote of thanks. I think we have all enjoyed Mr. Tinker's lecture very much, and I think he has covered so much ground that he has left very little room for any questions and this has, I think, been the reason for so few questions being raised in the discussion. It has been a most interesting and instructive lecture, and I have great pleasure in voicing the feelings of all of us in proposing a vote of thanks to Mr. Tinker.

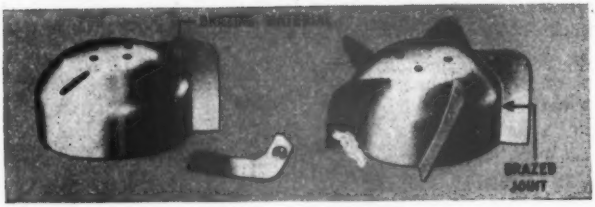
The meeting then examined a large number of samples of electric furnace-brazing brought down by Mr. Tinker.

Illustrations by courtesy of BIRLEC LTD.



Brazed Fan Pulley fabricated from three pressings and one Capstaned Boss

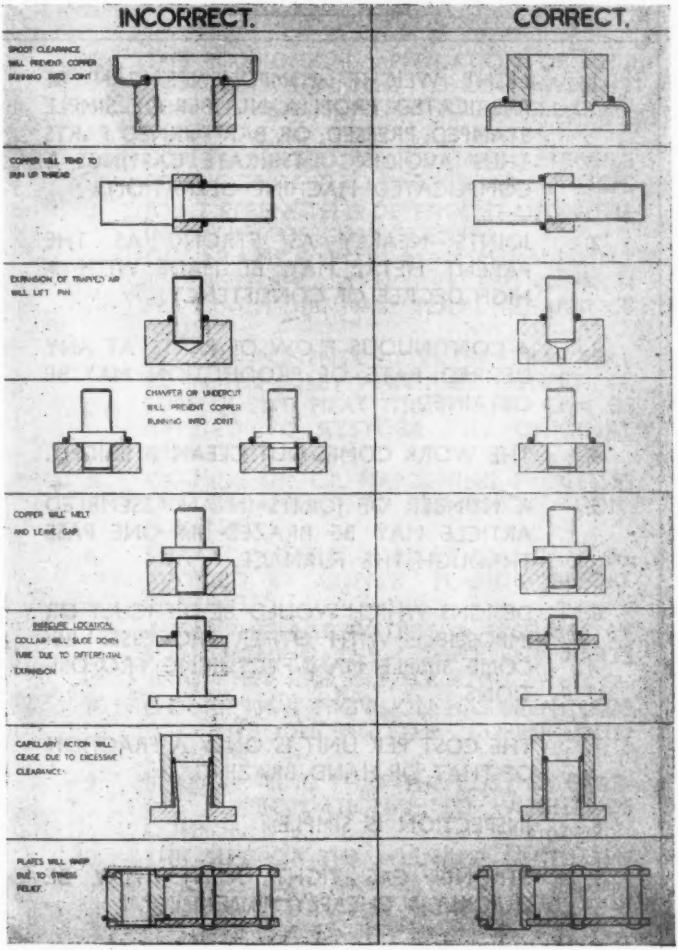
Typical Copper Brazed Assemblies



Brazed Fuse Impeller

COPPER BRAZING.

TYPICAL FAULTS & THEIR REMEDIES.


INCORRECT.
CORRECT.
SPIGOT CLEARANCE WILL PREVENT COPPER RUNNING INTO JOINT
COPPER WILL TEND TO RUN UP THREAD
EXPANSION OF TRAPPED AIR WILL LIFT PIN
CHAMFER OR UNDERCUT WILL PREVENT COPPER RUNNING INTO JOINT
COPPER WILL MELT AND LEAVE GAP
INSECURE LOCATION
COLLAR WILL SLIDE DOWN TUBE DUE TO DIFFERENTIAL EXPANSION
CAPILLARY ACTION WILL CEASE DUE TO EXCESSIVE CLEARANCE
PLATES WILL WARP DUE TO STRESS RELIEF

COPPER BRAZING

ADVANTAGES.

1. LIGHT WEIGHT COMPONENTS CAN BE FABRICATED FROM A NUMBER OF SIMPLE STAMPED, PRESSED, OR BAR TURNED PARTS THUS AVOIDING INTRICATE CASTINGS & COMPLICATED MACHINE OPERATIONS.

2. JOINTS NEARLY AS STRONG AS THE PARENT METAL MAY BE MADE WITH A HIGH DEGREE OF CONSISTENCY.

3. A CONTINUOUS FLOW OF PARTS AT ANY DESIRED RATE OF PRODUCTION MAY BE OBTAINED.

4. THE WORK COMES OUT CLEAN & BRIGHT.

5. A NUMBER OF JOINTS IN AN ASSEMBLED ARTICLE MAY BE BRAZED IN ONE PASS THROUGH THE FURNACE.

6. DESIGNS WHICH WOULD BE DIFFICULT OR IMPOSSIBLE WITH OTHER PROCESSES BECOME SIMPLE MANUFACTURING PROPOSITIONS.

7. THE COST PER UNIT IS ONLY A FRACTION OF THAT OF HAND BRAZING.

8. INSPECTION IS SIMPLE.

9. STRONG GAS-TIGHT JOINTS MAY BE QUICKLY & CHEAPLY MADE.

COPPER BRAZING

DESIGN HINTS.

1. THE ECONOMICAL APPLICATION OF THIS PROCESS IS CONFINED TO LIGHT WEIGHT LOW CARBON CONTENT MILD STEEL COMPONENTS.
2. COPPER BRAZED JOINTS HAVE A TENSILE STRENGTH OF 18 TO 24 TONS PER SQ. INCH.
3. JOINT STRENGTH IS DEPENDENT UPON THE INITIAL FIT OF COMPONENTS. CLEARANCE FOR MAXIMUM JOINT STRENGTH SHOULD NOT EXCEED ·001 INCH PER 1 INCH DIA. MAX. TOTAL CLEARANCE ·003".
4. ALL COMPONENTS AFTER BRAZING WILL BE IN THE FULLY ANNEALED CONDITION. SUBSEQUENT HEAT TREATMENT CAN BE APPLIED TO RESTORE THE ORIGINAL QUALITIES.
5. CYANIDE OR OIL HARDENING PROCESSES CAN BE APPLIED TO THE BRAZED COMPONENTS.
6. SURFACE DECARBURISATION CAN BE AVOIDED BY COPPER PLATING BEFORE BRAZING.
7. AVOID THE USE OF JIGS & FIXTURES BY SO DESIGNING THE COMPONENT PARTS THAT THEY ARE SELF LOCATING.
8. ENSURE THAT PROVISION HAS BEEN MADE FOR INTRODUCING THE COPPER INTO THE JOINT.
9. BEAR IN MIND THAT THE COST OF BRAZING IS PROPORTIONAL TO WEIGHT OF COMPONENT.
10. THE SIZE OF THE FURNACE LIMITS THE SIZE OF ANY ASSEMBLY TO 12 INCHES WIDE × 4·75 INCHES HIGH.

INSTITUTION NOTES

August, 1945.

Appointment of Director-General Secretary

The appointment of Major C. B. Thorne, M.C., as Director-General Secretary of the Institution has now been confirmed.

In the course of an interesting career, involving much travel, Major Thorne was recalled from the Regular Army Reserve for service on the General Staff in August, 1939. Eventually his work became concentrated from June 1942, in writing war commentary and broadcasts. These covered the U.S.S.R., the U.S.A., the Middle East, and the British Dominions. In addition to the foregoing he gave many lectures to the fighting services on the general war situation, embracing all the major aspects of total war—political, economic and military—along with matters of a more technical nature such as combined operations, transportation by land, sea and air, bridging, gunnery and reconnaissance in the field. This work was concluded with the publication of "St. George and the Octopus," already acknowledged to be one of the outstanding histories of the war. This book deals with events leading up to the war and certain political, economic and military aspects of the second world crisis.

Major Thorne comes to the Institution with a considerable reputation for vision, drive and administrative ability, not only amongst authors and literateurs, but also in service circles.

1945.

August Meetings.

— Wolverhampton Graduate Section. A lecture will be given by Dr. Chapman on "The Graduate's Approach to Management Problems." Full details to be announced later.

September Meetings.

5th Manchester Graduate Section. A lecture will be given by R. W. Eade, B.Sc., on "Radiology as Applied to Production," at the College of Technology, at 7-15 p.m.

8th Shrewsbury Sub-Section. A lecture will be given by B. Thomas, Esq., on "The Theory of Ferrous Heat Treatment." at the Technical College, Shrewsbury, at 3.0 p.m.

12th Manchester Section. A lecture will be given by Austin Hopkinson, on "Full Employment in Industry," at the College of Technology, Manchester, at 7-15 p.m.

September Meetings—*continued.*

17th Derby Sub-Section. A lecture will be given by Dr. K. G. Fenelon, M.A., on "Environment and Output," at the School of Art, Green Lane, Derby, at 6.30 p.m.

21st Manchester Section. A lecture will be given by W. Puckey, M.I.P.E., on "Managerial Aspect of Full Employment in Industry," at Mechanics' Institute, Crewe, at 7-15 p.m.

22nd Manchester Section. A lecture will be given by W. Puckey, M.I.P.E., on "Managerial Aspect of Full Employment in Industry," at Liverpool University, at 2-30 p.m.

— Wolverhampton Graduate Section. A lecture will be given on "Negative Rake Machining," at Wisemore Schools, Walsall. Full details to be announced later.

28th North-Eastern Section. A lecture will be given by Dr. D. F. Galloway, B.Sc., on "Production Engineering Research," at the Neville Hall, Newcastle-on-Tyne, at 6.15 p.m.

October Meetings.

— Wolverhampton Graduate Section. A lecture will be given by J. Styles, Esq., on "Design and Manufacture of Cutting Tools," at Dudley and Staffordshire Technical College, Dudley, at 7-0 p.m. Full details to be announced later.

8th Manchester Graduate Section. A lecture will be given on "Steel Making and Rolling," by Dr. D. Binnie, at the College of Technology, at 7.15 p.m.

11th Leicester Section. A lecture will be given by Dr. W. Wilson of the G.E.C. Development Department on "Electronics in the Service of the Engineer," at Leicester College of Technology, at 7-0 p.m.

15th Derby Sub-Section. A lecture will be given by E. W. Hancock, M.B.E., M.I.P.E., on "Time Factor in Industry," at the School of Art, Green Lane, Derby, at 6.30 p.m.

17th Manchester Section. A lecture will be given by A. G. Doughty, Esq., Ministry of Health and National Service, on "Use of Disabled Personnel in Industry," at the College of Technology, Manchester, at 7-15 p.m.

19th Western Section. A lecture will be given by F. L. Daniels, M.I.P.E., M.I.Mech.E., F.G.S., on "Geology in Engineering," at the Grand Hotel, Broad Street, Bristol, 1, at 6.45 p.m.

October Meetings—*continued.*

20th Manchester Graduate Section. Visit to L.N.E.R., Gorton.

20th Shrewsbury Sub-Section. A lecture will be given by N. Matthews, Esq., on "Principles of Foundry Practice," at the Shrewsbury Technical College, at 3.0 p.m.

August Committee Meetings.

20th The Research Committee at Loughborough, at 11.45 a.m.

24th The Finance and General Purposes Committee at Institution Head Office, at 2.30 p.m.

28th The Education Commitee at the Imperial Hotel, Birmingham, at 10-30 a.m.

28th The Membership Committee at the Imperial Hotel, Birmingham, at 12-30 p.m.

— The Technical and Publications Committee meet every Wednesday at Institution Headquarters, at 5-30 p.m.

Personal.

D. R. Burns, Esq., M.I.P.E., has left the North British Rubber Co., Ltd., Edinburgh, in order to take up an appointment as General Manager with the United Turkey Red Co., Ltd., Alexandria, Dumbartonshire.

A. O. Williams, Esq., M.I.P.E., Assistant Works Manager of Helliwells, Ltd., and Manager of the firm's B.13 Factory on the Treforest Trading Estate, received a farewell gift at the Upper Boat Hotel on terminating his connection with the firm.

Control Commission for Germany.

The Institution has been approached by the Economics Division of the above Commission with the request to help them in finding suitable candidates for their Shipbuilding Branch. Staff of two kinds are required: (1) Administrative Staff to direct operations from headquarters and deal with matters of policy; (2) Staff of Executive Officers qualified to carry out control and investigation in shipyards and factories.

It is against the policy of your Council to deal with appointments but, in view of the national importance and extreme urgency of this matter, it was decided to publicise these vacancies. Potential candidates should apply for full particulars to: Control Commission for Germany (British Element), Economics Division, Shipbuilding Branch, Flat 112, Room 2, Ashley Gardens, S.W.1. Telephone: VICtoria 3858, Ex. 127.

IMPORTANT !

In order to get the Journal out to time copy must reach the Head Office of the Institution by not later than 40 days prior to the date of issue, which will be the first of each month.

Books Received.

Proceedings January/December, 1944. Vol. 151 of the Institution of Mechanical Engineers.

Employment Tests in Industry and Business. Issued by the Department of Economics and Social Institutions, Princeton University, U.S.A.

BOOK REVIEW.

Report of the Committee on Safety in the Use of Power Presses, 1945. (Issued by H.M. Stationery Office.)

The question of safety devices for use with power presses is a subject that needs much thought both from the manufacturers' and users' point of view if accidents are to be prevented.

The report, which has been compiled by technical experts, includes valuable information in connection with the guarding of power presses, and the recommendations set out for manufacturers and users should be carefully studied by all those interested in the manufacture and use of these machines.

Suggestions are made to assist the designers and manufacturers, and "do's" and "dont's" are quoted, covering the training of operators in the use of these machines. Illustrations are shown of interlocked fixed guards incorporated in the design of the machines.

Interlocked fixed guards applied on an existing press. Static fixed guards, etc. The Committee are to be congratulated on producing such a valuable document.

A. ROBERTS, M.I.P.E.

Research Department: Production Engineering Abstracts

(Prepared by the Research Department.)

NOTE.—*The Addresses of the publications referred to in these Abstracts may be obtained on application to the Research Department, Loughborough College, Loughborough. Readers applying for information regarding any abstract should give full particulars printed at the head of that abstract, including the name and date of the periodical.*

ACCOUNTING, ADMINISTRATION.

Costing in the Small Works. (*Mechanical World, 29th June*, 1945, *Vol.* 117, *No.* 3052, *p.* 712.)

Details of a system which has been successfully adopted by small concerns of up to 100 employees to give (1) the costs ; (2) a basis for a method of incentive payments ; (3) the running costs of cash department ; (4) overhead expense control ; (5) a loss or gain per order executed ; (6) allocation and recovery of expenses ; (7) a basis for the interlocking of the financial and cost accounting systems ; and (8) the value of work in progress.

Cost and Quantity, by Paul Grodzinski. (*Mechanical World, 1st June*, 1945, *Vol.* 117, *No.* 3048, *p.* 599, 10 *figs.*)

A study of the fundamental relationship between production cost and the number of articles produced.

BELTS, ROPES.

The Significance of Pitchline Measurement in V-belt Technique, by J. A. Hardman. (*Power Transmission, June* 15th, 1945, Vol. 14, No. 161, p. 471, 3 *figs.*)

The factors affecting the belt proportions under operating conditions are carefully considered and their effects on belt design are indicated, *e.g.*, the distribution of the cords and rubber. The measurement of the pitch lengths of V-belts is an important operation, particularly in the case of belts intended for use on multiple drives. It is concluded that it is satisfactory to determine the pitch-lengths of V-belts by a method outlined, using the nominal pitch diameter of the measuring pulleys as a basis of computation, provided that some restriction is placed on the permissible variations in riding positions of the belts in the grooves.

Some Belt Drive Problems, by Edward Ingham. (*Power Transmission, June* 15*th*, 1945, *Vol.* 14, *No.* 161, *p.* 481, 3 *figs.*)

These include difficulties due to slipping, wobbling, flapping, dirt, static electricity and wear.

ELECTRICAL ENGINEERING.

Electronic Control. (*Aircraft Production, June*, 1945, *Vol. VII, No.* 80, *p.* 261, 8 *figs.*)

The application of electronic control to electric resistance welding and riveting is reviewed and an indication given of its advantages in the automatic control and co-ordination of variable factors. The operation of the control unit of the riveter is described in some detail with the aid of diagrams.

Principal Limitations of Dielectric Heating, by Carl J. Madsen. (*Machine Shop Magazine, June*, 1945, *Vol.* 6, *No.* 6, *p.* 80.)

These limitations are discussed in detail: they must be recognised if success is wanted.

EMPLOYEES, ETC.

Demobilisation of Staff. (*Industrial Welfare, May-June*, 1945, *Vol. XXVII, No.* 300, *p.* 85.)

A scheme established by the Courtauld Group of companies, to apply as a minimum basis to all monthly and weekly paid male and female staff of these companies, is intended to ensure that all employees shall receive a fair and practical welcome on their return to normal work, and that the spirit underlying conditions of employment shall contribute to their general satisfaction and happiness within the undertaking.

Soviet Ball-Bearings, by V. Chevychelov. (*Machine Shop Magazine, June*, 1945, *Vol.* 6, *No.* 6, *pp.* 36, 12 *figs.*)

This brief non-technical article indicates the breadth of vision with which industrial problems are tackled in Soviet Russia, and the way in which the personnel angle is looked after.

MACHINE ELEMENTS.

Lubrication of Anti-friction Bearings, by I. C. de Martonfalvy. (*Mechanical World, 29th June*, 1945, *Vol.* 117, *No.* 3052, *p.* 709.)

The importance of lubricating ball and roller bearings is not always recognised. The functions of lubricants are chiefly to provide a tenous film in order to minimise the rolling friction between the balls and rollers and their races, and the sliding friction between balls and rollers and their retainers. The lubricant must also protect the highly finished surfaces from corrosion, aid in the dissipation of heat and assist in preventing intrusion of dirt, etc. Research has proved that friction in a ball or roller bearing will be lowest with a quantity of oil just sufficient to form a thin film over the contacting surfaces. Friction will increase with greater quantity and with higher viscosity of the oil. The selection of the lubricant should be based on operating temperature, speed and load. From the point of view of lubrication, oils are preferable to greases, but the latter are easier to use and permit simpler and cheaper design. Suitable oils and greases are recommended for specific conditions and some gencral comparsons of the features of ball, roller and plain bearings are also made.

MACHINING, MACHINE TOOLS.

The British Machine Tool Industry, by L. A. Ferney. (*The Engineer*, 1*st June*, 1945, *Vol. CLXXIX, No.* 4664, *p.* 424, 2 *figs.*)

Part II. In 1939 the German machine tool trade was much larger than the British one, and the quality of its products was generally speaking considerably higher. Whereas in the U.K. there was an average of 180 operatives per factory, in Germany there was an average of 400 per factory. Several works could build any machines to customer's design, or develop special machines for a particular duty. This class of builders was particularly scarce in this country. The German trade was primarily responsible for the development of hydraulic drives, their electrical equipment was carefully thought out, and it was quick to realise the advantages of co-operative action in production. The American industry has been in the forefront of precision and high-production machine tools since the end of the last century. It produces some of the finest multi-spindle automatics, and may be said to lead the world in milling and grinding machines. American machines in many cases cost twice as much as corresponding British or German machines, but there was a market for them throughout the world because of technical advantages, proving that expensive products can be sold on quality, rapid delivery, and good design. By 1939 there were in the U.S.S.R. about a dozen machine tool works of considerable size, and also a Machine Tool Research and Development Institute (Enims), reputed to employ 2,000 to 3,000 people. Less than 10,000 people were employed in the French machine tool industry, and the production was insufficient for French needs. This was reflected in the relatively poor mechanical equipment of the French engineering industry. The turnover of the British industry increased from £19,000,000 in 1939 to £47,000,000 in 1942. The number of people employed rose from 25,000 in 1937 to 85,000 in 1942. Improvements in design, and methods of production brought the machine tool trade nearer to the standards of Germany and U.S.A., but the British engineering industry was compelled to go to America for many special tools. M.T.C. exercised very considerable powers, including rationalisation. The industry increased its capacity by sub-contracting. Nothing has been done by the Control seriously to affect the immediate profits or prospects of the industry. Little constructive work was done either in the way of standardisation of machines or parts thereof, or of improved methods of production or improvements in design, but fuller advantage has been taken of recognised improvements, such as carbide tools and climb milling. The lease-lend tools from the U.S.A. placed the British trade in a difficult position with regard to exports. A further adverse effect was that there was no impetus to produce certain new types of machines, which we would otherwise have been forced to design and produce. Many are pessimistic about post-war prospects, but many machine tools are obsolete or worn out, and many could be utilised in the rehabilitation of Allied countries. Further, India, Brazil, and the Near East will require vast quantities of machine tools, and for the British engineering industry to remain efficient, it must re-equip itself. An estimate of domestic requirements is 8 to 10 million pounds annually for three to five years. The prospects of the export trade will largely depend on political decisions. A table has been drawn up showing world machine tool trade for the first post-war year. It assumes that the British exports in the post-war period could be raised four times as compared with 1937. In conclusion, it is stated that the main shortcomings of the British machine tool trade are lack of standardisation, absence of any serious research work, and the uneconomical size of the factories. The following recommendations are advanced : (1) A national machine tool laboratory to be founded, employing about 2,000 people. (2) Chairs of production engineering should be formed at at least three universities.

Machine Tool Problems, by F. M. Shaw. (*Machine Shop Magazine, June,* 1945, *Vol.* 6, *No.* 6, *p.* 42.)

Remarks about the prospects for the machine tool industry have produced comments which show a marked pessimism. This arises from the following: (1) A surplus of used and new machine tools; (2) Prospective world excess of capacity for making new machine tools; (3) The desire to obtain war compensation from Germany. It must be made clear that our national economy cannot afford to have an inefficient industry, even if we assume that there will never be another war. The general engineering trades cannot be competitive in the markets of the world unless they are served by a most up-to-date machine tool industry; nor can machine tools be exported unless this condition is fulfilled. Before the war a great variety of high-class machine tools were imported, because British makers had not sufficient business to encourage them to embark on the costly effort to create new types, and we allowed our markets to be swamped by second-hand tools. The average American machine tool user has a mentality differing from that prevailing here. To him, the value of a machine is not inseparably tied up with its initial price, but almost only with the service it can give. Most British users are not satisfied unless they get many years of service, even if it could be proved that a more advanced type of machine would very quickly justify the new outlay. A government that wants to encourage export trade should discourage the false economy of using machine tools too long. Engineering firms should be allowed to write off machine tools in an average period of four to five years. A restriction should be put on the use of surplus and over-age machine tools rather than on the making of new ones. War compensation from Germany is unsatisfactory and undesirable.

Milling Data Charts. (*Production Engineering Research, June,* 1945, *Vol.* 4, *No.* 30, *p.* 230.)

Charts and data contributed by Machine Tool Control give values within approximately 5 per cent. of those determined by calculation for spindle speed, table feed, number of teeth, cut and horsepower.

Small-Hole Grinding with Diamond-Charged Mandrels, by Frederick C. Victory. (*The Machinist, 2nd June,* 1945, *Vol.* 89, *No.* 8, *p.* 265, 8 *figs.*)

Round, straight holes in dies and gauges can be produced to tenths faster with a mandrel charged with the proper grade of diamond dust than by use of small mounted wheels.

MANUFACTURING METHODS.

Management can make more Use of Time Study, by Ralph A. Stearns. (*Machine Shop Magazine, June,* 1945, *Vol.* 6, *No.* 6, *p.* 55.)

Some basic contributions of time study engineers are set forth that are too often overshadowed by the rate setting function. The author suggests amplified uses of records, tables and observations developed by the time study department.

Time and Motion Study, by John W. Hendry. (*Automobile Engineer, April,* 1945, *Vol. XXXV, No.* 461, *p.* 155, 6 *figs.*)

Motion economy can be described as being the science of eliminating waste effort and the correction of wrong motions. The motion economist's aim is to get the same results for less expenditure of energy by: (*a*) motion study, which analyses the mechanics by which motion economy is introduced, (*b*) assess-

ing the minimum effective effort-performance, and (*c*) job simplification, that is jig and fixture design, layout and a study of operator needs. After pointing out that the frame of mind of the operator will have considerable bearing on the results, and the fullest publicity must be given to aims and objects, the article describes the carrying out of an effective motion study. Work is divided into : (*a*) prepare, (*b*) doing, and (*c*) clear up. (*a*) and (*c*) are important, but (*b*) is most important of all. The importance of eliminating fatigue is stressed, and the basic factors affecting each job are then listed. Motion study factors are set out in detail and are amplified by general machine shop and assembly shop examples. In conclusion notes are given on the reaction of supervisors and operators, and the effects on incentive schemes.

What an Engineer Can Do in a Small Plant. (*Mechanical Engineering* (*U.S.A.*), *May*, 1945, *Vol.* 67, *No.* 5, *p.* 330.)

Three short articles on product planning, plant layout and shop equipment.

Cubicles and Control Desks, by F. T. Bennell. (*Mechanical World*, 8*th*, 15*th*' *and* 22*nd June*, 1945, *Vol.* 117, *Nos.* 3049, 3050 *and* 3051, *pp.* 625, 672, *and* 687, 20 *figs.*)

The planning and manufacture of standard steel housings for electrical equipment is described in detail, and sections are devoted to methods of cubicle construction, arrangement of equipment, mounting of meters, rolled sections for frames, welding or bolting, welded joints, drilling, top panels, doors and covers, dustproof covers, and control desks.

MATERIALS.

Engineering Materials, by Archibald Black. (*Mechanical Engineering* (*U.S.A.*), *May*, 1945, *Vol.* 67, *No.* 5, *p.* 335.)

Part 4. Glasses, woods, and glues, miscellaneous materials, and processes. This article reviews recent progress and includes information on : glass-fibre, special plate glasses, industrial and optical glasses, glass gauges and glass bearing jewels ; modern glues and plywood, glues for metals, chemical treatment of wood, wood and paper inpregnation and impregnated-wood bearings ; abrasives, powder metallurgy and sintering, luminescent materials, black finishes, electroplating of non-conductive materials, electropolishing ; and applications of supersonic vibration, machinability studies, damping properties, refractory materials and hardness-tensile strength conversion tables for metals. An extensive bibliography is given.

SHOP ADMINISTRATION.

Planning and Projecting Heavy Industries in the U.S.S.R., by A. Laszlo. (*Mechanical World*, 8*th and* 15*th June*, 1945, *Vol.* 117, *Nos.* 3049 *and* 3050, *pp.* 628, 663.)

An outline of the technical organisation developed for a definite purpose, and the functions of the departments, based on the author's experience during the first five-year plan in connection with the design and projecting of tube mills.

The Planning Department, by D. Tiranti. (*Mechanical World*, 22*nd June*, 1945, *Vol.* 117, *No.* 3051, *p.* 681.)

The function of this department is the planning and direction of work so that a studied method can be prepared and tabulated so that all can work together as a co-ordinated team, with the result that work is not only done in an organised manner, but is also carried out with due regard to costs and economic produc-

tion. The author analyses the fundamental requirements of such a department, with particular attention to its place in the general factory scheme, and illustrates his findings by a working example.

SMALL TOOLS.

What Should Tools Cost, by Michael Watts. (*Machine Shop Magazine, June,* 1945, *Vol.* 6, *No.* 6, *p.* 49, 1 *fig.*)

During the war tool costs have risen considerably, due mainly to (1) fluctuation in the value of money, and (2) problems concerned with labour, and there is some danger that they may have come to be accepted as normal. The writer has made a comparison between pre-war and present tooling costs by selecting two examples of simple average press tool jobs made before the war, and comparing the known costs of the tools with an estimate of what they would cost to-day, resulting in increases of 20 and 56 per cent. in man-hours. The chief difference appears to lie in the question of the use of skilled hand methods compared to machine methods. With the former the job is handled completely by one man ; with the latter, the work is split up between several specialists, probably semi-skilled. The skilled man does most of the work on the bench or with simple machines, and in less time. We should be more likely to achieve maximum utilisation of man-power by ensuring that all workers are fully skilled, and after the cessation of hostilities there should be no shortage of skilled men.

Precision-cast High-speed Steel. (*Machinery, June* 14*th,* 1945, *Vol.* 66, *No.* 1705, *p.* 641, 8 *figs.*)

An application of the waste-wax method of mould making has enabled large economies to be effected in the making of high-speed steel cutters by precision casting. More than 10,000 cutters have been produced in the Ford laboratory for use in the company's machine shops. Except for sharpening the cutting edges and grinding-off risers, these cutters require no finishing. The bores are used as cast. The technique followed in this plant is described.)

Sub-Zero Treatment of Steel Increases Hardness and Stability, by Charles M. Parker. (*The Machinist, 2nd June,* 1945, *Vol.* 89, *No.* 8, *p.* 274, 3 *figs.*)

A three-to six-fold increase in pieces per grind is reported for high-speed steel tools subjected to cold treatment. This article attempts to explain the underlying reasons for this improvement.

Modified Drill Design. (*Machinery, June* 28*th,* 1945, *Vol.* 66, *No.* 1707, *p.* 697, 7 *figs.*)

Difficulty was encountered in drilling large deep holes in landing-gear hydraulic cylinders, 4½ inches in diameter and 26 inches deep, of S.A.E. 4340 steel forgings. With a high-speed steel spade drill of usual design, the drilling time was 2 to 2½ hours per hole, and after each hole was drilled, the drill had to be reground. A modified design of spade drill was found to need only 47 minutes and 7 holes were drilled between resharpenings. The modified design includes a slot across the point of the drill, chamfered corners and primary and secondary clearances. Experiments were begun with conventional twist drills modified in a similar fashion and an example is given, with production figures. The grinding procedure for modifiying conventional twist drills is described.

Carbide Tool Inspection, by D. P. Walsh. (*Machine Production, March,* 1945.)

A method of inspecting carbide-tipped tools for cracks is described, which involves the use of a fluorescent penetrant fluid. The fluid is retained in cracks or other surface defects and is caused to fluoresce when viewed under near

ultra-violet light. Not only can the tip itself be inspected, but the braze also comes under the influence of the fluorescent material and the "black" light. Reference is made to causes of defects and the various steps that can be taken for reclaiming cracked tools.

(*Communicated by Machine Shop Magazine.*)

Special Rake Angles Used for Sintered Carbide Tools, by M. Martellotti. (*The Machinist*, 2*nd June*, 1945, *Vol.* 89, *No.* 8, *p.* 280, 5 *figs.*)

Part 7. When choosing rake angles for milling cutters the effective rake should be kept in mind. The author tells how to calculate it, and gives alignment charts and tables of values for various cases.

Further Tests Reported on Carbide Hobs. (*The Iron Age*, 15*th March*, 1945.)

Roughing was done with a hob at 133 r.p.m. with a climb feed of 0.040 in. per revolution of the gear blank and a peripheral speed of 200 ft. per min. The hob was 6 ins. dia., 5-pitch single start with a 2½ ins. bore. Near the end of the cut the hob was damaged ; it was subjected to what was virtually a destructive test, so that its capacity and operating range might be determined. Failure of the hob indicated the need for certain modifications in design and in the selection of the carbide cutting edges. It was estimated that a hob held to proper tolerances would rough out a steel pinion for a C-3, 8,500 h.p. turbine gear in 5 hrs. 40 mins., as compared with the usual time of 27 to 30 hrs. on a standard machine with a high-speed steel hob running at 35 to 40 r.p.m. The blank used in the tests was about 50 per cent. harder than that used in practice. Other tests are described.

(*Communicated by Machine Shop Magazine.*)

Fellows Gear Cutters. (*Mechanical World*, 8*th June*, 1945, *Vol.* 117, *No.* 3049, *p.* 631, 4 *figs.*)

A method has been devised for producing, on gear milling and grinding machines, the cutting wheels necessary for the Fellows' generating process. The method, which in particular refers to a Pfauter gear milling machine and a Maag gear grinding machine, has been obtained from a German source.

SURFACE, SURFACE TREATMENT.

Surface Roughness, Waviness and Lay. (*Engineering*, 15*th June*, 1945, *Vol.* 159, *No.* 4144, *p.* 474, 3 *figs.*)

This article discusses a new draft of the proposed American Standard B.46 for Surface Roughness. The standard establishes classifications for various degrees of roughness and waviness, and for varieties of "lay." This last term is defined as the direction of the predominant surface pattern. It perpetuates the loose distinction between roughness and waviness which leaves too much to the arbitrary judgment of the person analysing an instrumental record of surface finish and does nothing to solve an exceedingly vexed question. The standard does not define what degree of roughness or waviness, or what type of lay, is suitable for any specific purpose, nor does it suggest the means whereby any degree of such irregularities may be produced. Neither does it recommend the means, procedure or apparatus for measurement of roughness and waviness, nor mention that the roughness measure for a given surface may vary according to the characteristics of the instrument employed. The more detailed part of the draft standard is mainly concerned with the specification and evaluation of surface irregularities. Recommended classes of roughness and waviness are given.

The draft standard requires the height of the roughness or waviness to be specified in one of the following terms: maximum peak-to-valley height; average peak-to-valley height; or average (either r.m.s. or arithmetical) deviation from the mean surface. The list of suggested standard symbols for designating surface finish characteristics on drawings or in specifications or reports are reproduced, including those for lay. Among a number of points likely to evoke criticism is the tacit admission of the evaluation of a surface by comparison with reference specimens or observational standards, since this method lacks the precision demanded by modern methods.

Final Operations, by Dr. G. Schlesinger. (*Aircraft Production, June, July,* 1945, *Vol. VII, No.* 80, 81, *pp.* 266, 350, 36 *figs.*)

Part I. Requirements to obtain good quality surface finish. Methods of measurement. A survey of finishing processes.

Part II. Polishing, buffing and burnishing. Chipless forming operations. Bearings and spindles.

Metal Spraying by the British Wire Process, by G. C. Pitcairn. (*Engineering Materials, June,* 1945, *Vol. III, No.* 6, *p.* 119.)

A description is given of the apparatus necessary. The principal objects of metal spraying, the structure of sprayed metals, and the metals used are described and comparisons are made with welding and electro-deposition.

Cold Metal Spraying and its application to Internal Combustion Engines, by V. G. Young. (*Machinery Lloyd, June 9th,* 1945, *Vol. XVII, No.* 12, *p.* 56.)

The method now universally adopted is to feed in the metal in the form of a wire, to fuse it, and project it by controlled quantities of compressed air, oxygen and acetylene, or other suitable gas. The compressed air also operates a turbine which controls the rate of feed of the wire into the pistol. The material in general use for the building up of worn parts on a heavy-oil engine is 0.9 per cent. high-carbon steel. This has been found to be suitable for steel crankpins and journals, cast-iron pistons, steel valve stems, camshafts, etc. Stainless steel, bronze and zinc are also used for special purposes. The preparation of the surface to be coated is of paramount importance. The essentials are a rough surface to form a key for the sprayed metal, coupled with complete absence of moisture, oxidisation, and oil. The part is built up oversize so that it will just clean up when machined to finished size. Practical features are described with the aid of examples.

Shot-Blasting. (*Automobile Engineer, April,* 1945, *Vol. XXXV, No.* 461, *p.* 163.)

In the U.S.A. this is now widely employed to increase the fatigue strength of metals. The generally preferred technique is to discharge the shot from a wheel that is revolved at high speed. Means are provided whereby as much of the shot as possible strikes the surface of the material at an angle of 90 deg. Considerable importance attaches to the use of the correct shot, for form, chemical composition and size. Properly applied, the process increases appreciably the resistance to plastic deformation in the skin of the metal and the tensile strength immediately below the surface. The metal is in effect cold worked. Tables of fatigue strengths of "as received," polished and shot-peened specimens are given and gains up to 100 per cent. are listed.

TRANSPORT EQUIPMENT.

Developments in Continuous Materials-handling, by Frank H. Slade. (*Machinery Lloyd, June 9th,* 1945, *Vol. XVII, No.* 12, *p.* 47, 11 *figs.*)

Bulk handling for assembly and production and process handling equipment are included in this article which is general in nature.

Roller Conveyors. (*Production Engineering Bulletin, June,* 1945, *Vol.* 4, *No.* 30, *p.* 197.)

The use of simple roller conveyors.

WELDING.

The Welding of Non-ferrous Metals, by E. G. West. (*Sheet Metal Industries, June,* 1945, *Vol.* 21, *No.* 218, *p.* 1057, 8 *figs.*)

Part V. Arc welding processes.

Fabrication as a Substitute. (*Machinery, June* 21*st,* 1945, *Vol.* 66, *No.* 1706, *p.* 683, 3 *figs.*)

Welding and casting methods are compared. Typical examples are discussed.

INDEX TO ADVERTISEMENTS

As a war-time measure the advertisement section of this Journal is now published in two editions, A and B. Advertisers' announcements only appear in one edition each month, advertisements in edition A alternating with those in edition B the following month. This Index gives the page number and edition in which the advertisements appear for the current month.

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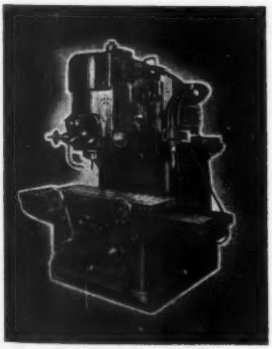

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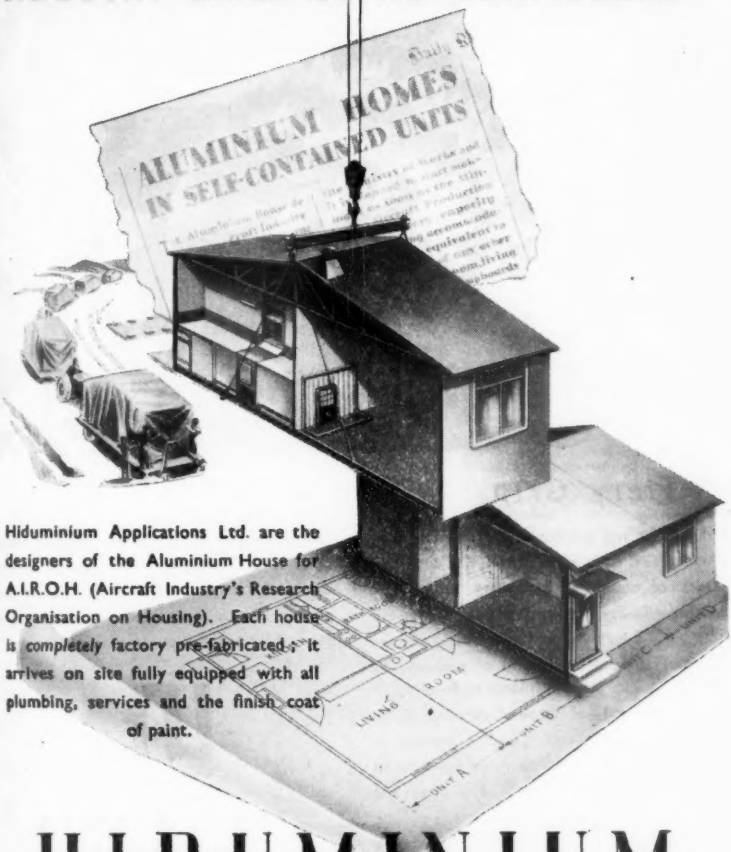

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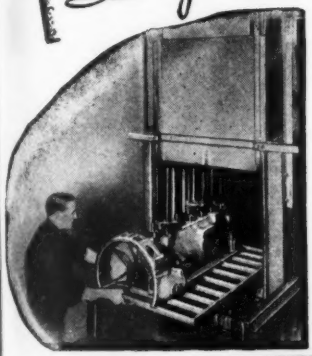

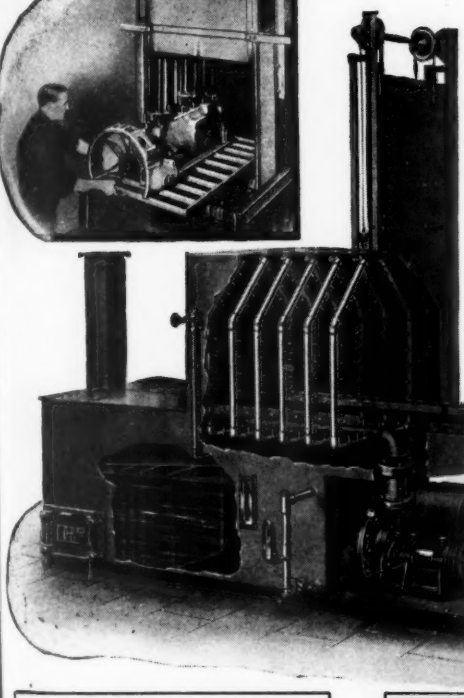

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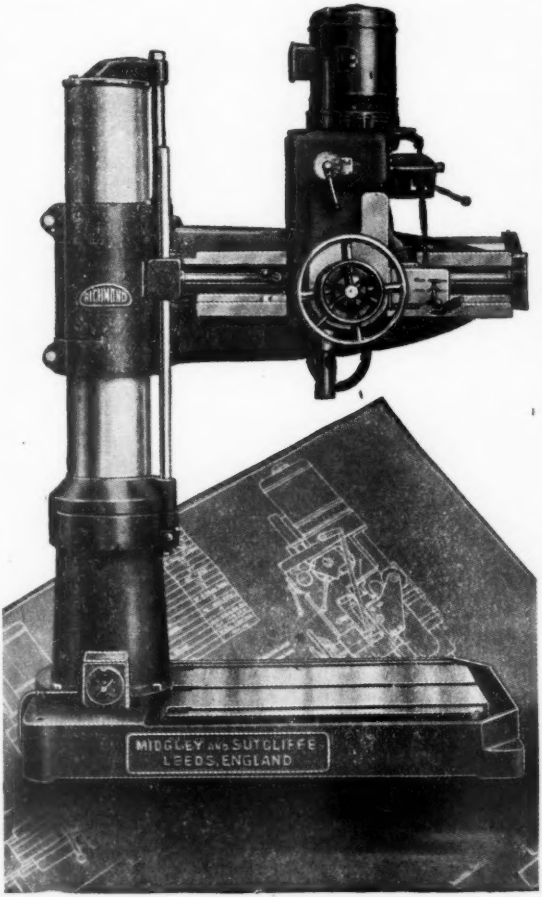

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Illustration shows Milwaukee Model 4K fitted with Wimet tipped negative angle cutter after removing 205 cu. ins. of metal from a 90 tons tensile steel block. The cutter had previously removed 600 cu ins. of metal from a 50 tons tensile steel billet and was not reground between the two operations.

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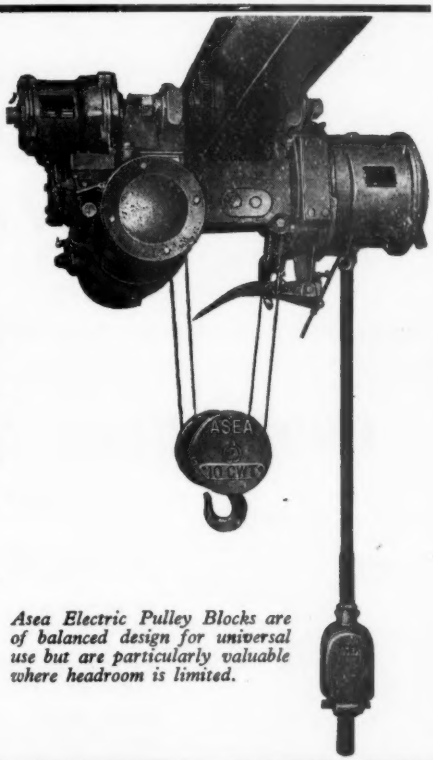

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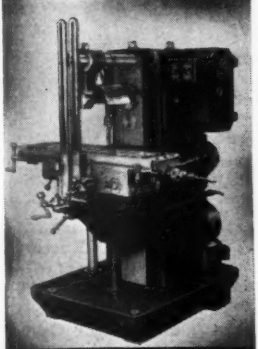
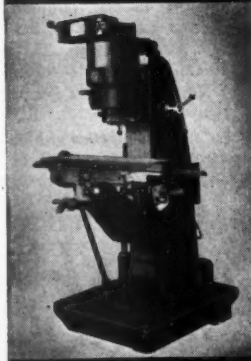
(1) 'I AM' MILLER



(2) '2 B' MILLER



(3) '2 VE' MILLER

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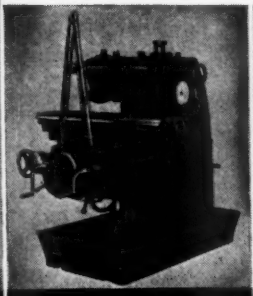
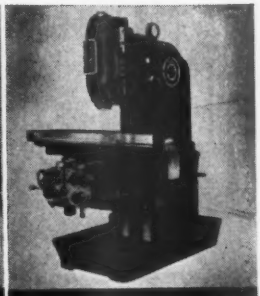
(4) "3" Horizontal Milling, Traverses 28 ins. by 8 ins. by 18 ins. Rapid Traverse all ways.

(5) "4V" Vertical Milling, Traverses 39 ins. by 15 ins. by 16 ins. Rapid Traverse all ways.



(4) '3' MILLER



(5) MODEL '4V' MILLER

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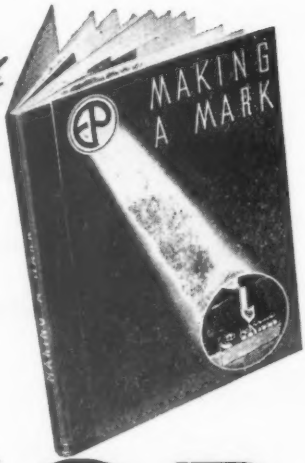

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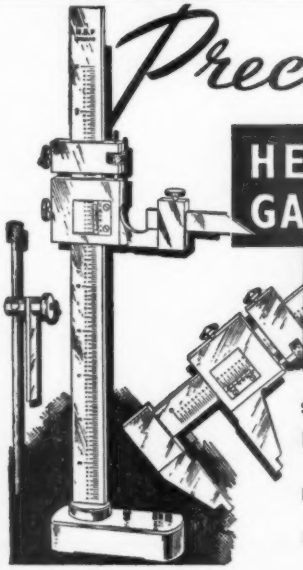

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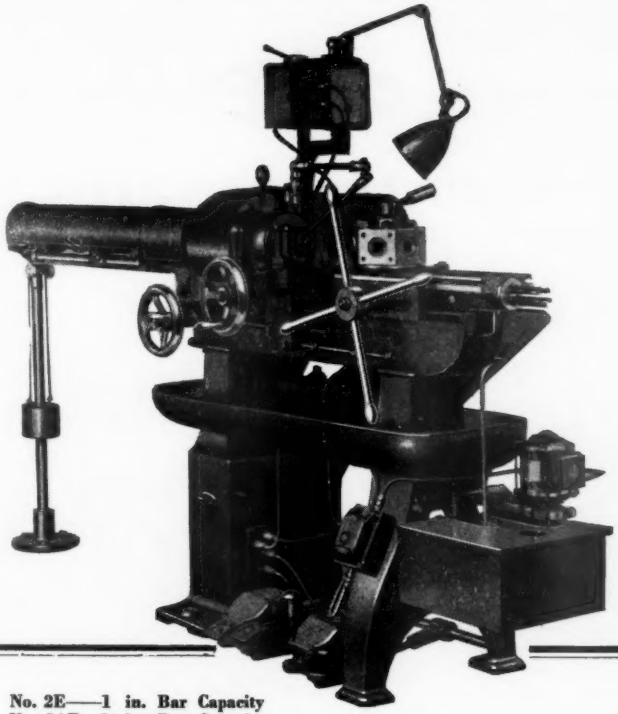

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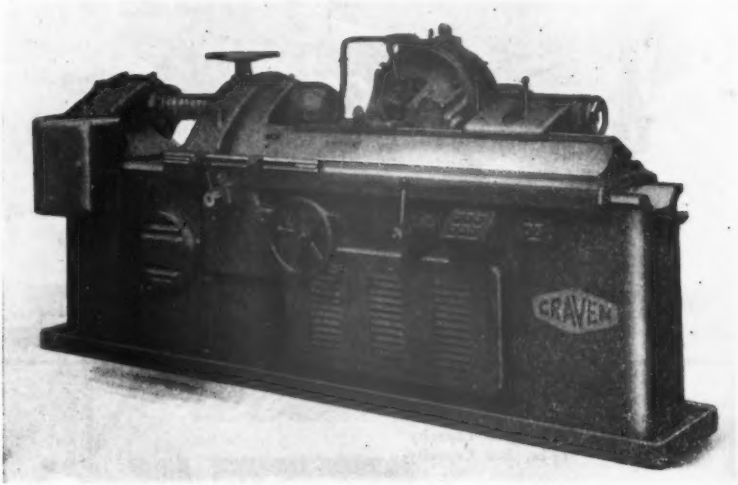

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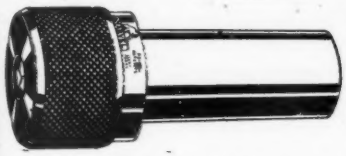

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